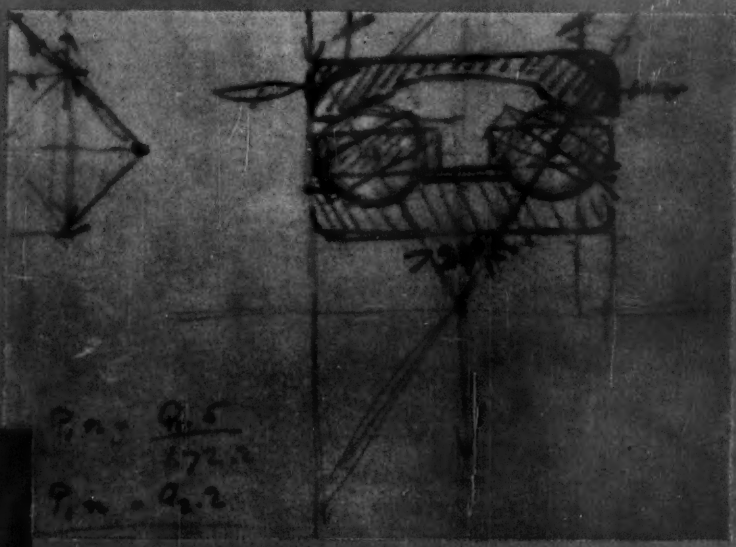
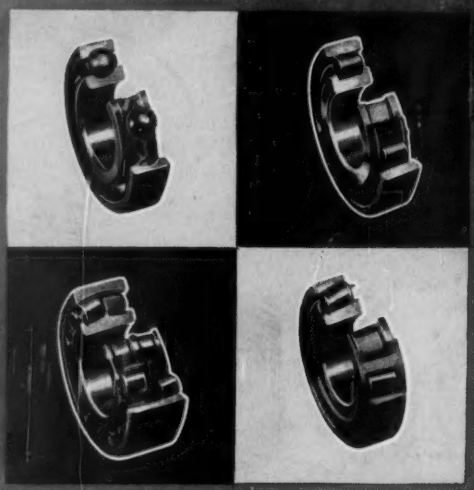
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 47 No. 6 **JUNE 1957** PRICE: 3s. 6d.

A reproduction of the first rough sketch of the double row self-aligning ball bearing, invented by Dr. Sven Wingquist the founder of **SKF**.





SKF

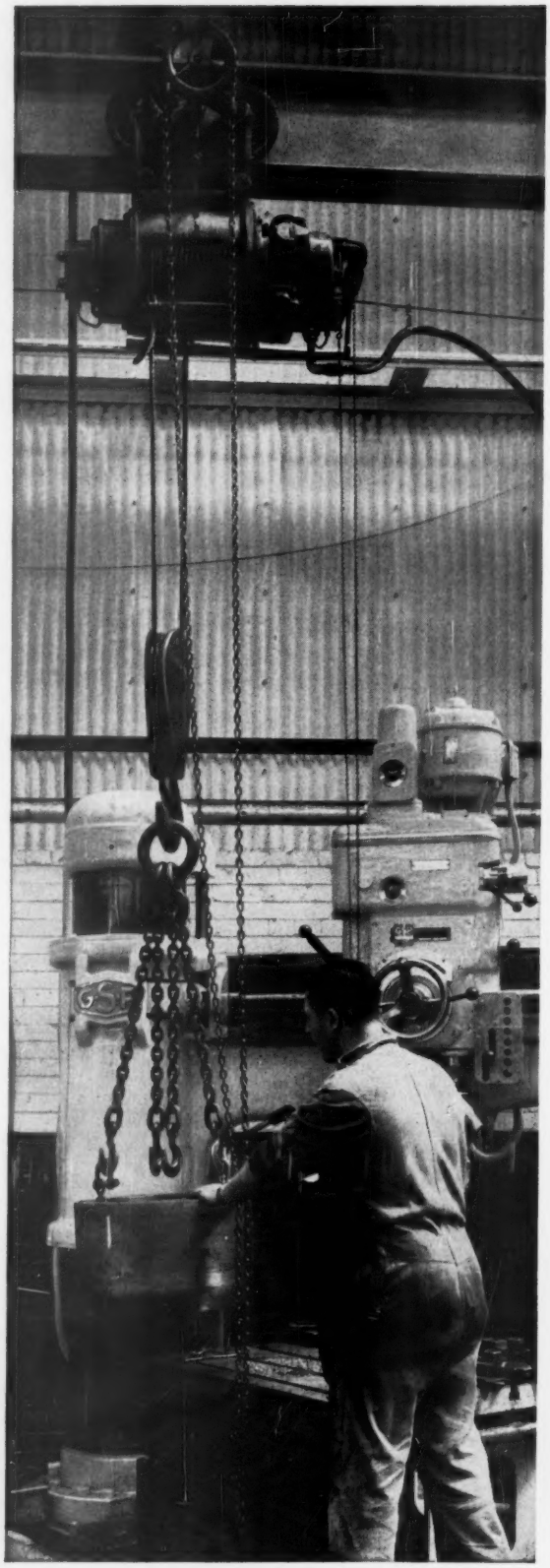
THE SKEFKO BALL BEARING COMPANY LIMITED
LUTON, BEDS.

The only British Manufacturer of all four basic bearing types:
BALL. CYLINDRICAL ROLLER. TAPER ROLLER. SPHERICAL ROLLER

fifty years of SKF

Fifty years ago, the invention of the double row self-aligning ball bearing marked the foundation of **SKF**. Three years later, in 1910, The Skefko Ball Bearing Company Ltd. was established in England, and manufacture commenced in Great Britain of **SKF** ball and roller bearings. Since then the **SKF** Organisation has become world-wide. It has always been in the forefront of anti-friction engineering and it has played a vital part in the progress of the engineering industry during the last half century. Today The Skefko Ball Bearing Company Ltd., as a member of this world-wide organisation, has at its disposal a unique fund of knowledge concerning bearing applications in every part of the world. Moreover, as the only British manufacturer of all four basic bearing types, the ball, cylindrical roller, taper roller and spherical roller, Skefko is in an unrivalled position to offer unbiased advice, whatever the bearing problem may be.

Twelve Atlas Copco Air Hoists do four years' precision work...



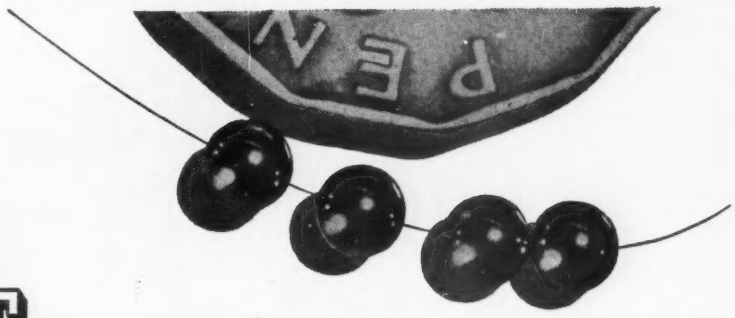
without a single day's failure. Four years ago Briggs Motor Bodies, a Ford subsidiary company, installed twelve Atlas Copco air-hoists in their Southampton factory. They have proved a most worthwhile investment. Atlas Copco air-hoists are easily controlled at low speeds without costly additional mechanism; this means that heavy parts can be lowered accurately with the minimum of manhandling. And it saves a great deal of time where accurate placing is vital. Furthermore, the radial air piston air motor's low air consumption makes the hoist very economical in operation. Add to this the fact that in this factory not one of the twelve air-hoists has broken down in four years' constant use, and you will see the obvious advantages Atlas Copco can give you.

World-wide sales and service

The Atlas Copco Group puts compressed air to work for the world. It is the largest group of companies specialising in the development and manufacture of compressed air equipment. It embraces Atlas Copco companies or agents manufacturing or selling and servicing Atlas Copco equipment in ninety countries throughout the world. For further details of the equipment featured here, contact your local Atlas Copco Company or Agent. If you have any difficulty, please write to:—Atlas Copco AB, Stockholm 1, Sweden, or Atlas Copco (Great Britain) Ltd, Beresford Avenue, Wembley, Middlesex.

742

Atlas Copco *Manufacturers of Stationary and Portable Compressors, Rock-Drilling Equipment, Loaders, Pneumatic Tools and Paint-Spraying Equipment*



TOP SECRET

Although tooling engineers have been quick to assess the possibilities inherent in the spark machining process and many interesting applications have become evident as a result, frequently there is a reluctance on their part to talk about these successes, or allow us to do so. For the march which spark-machining has helped them to steal on their competitors is a substantial one — too valuable, in fact, to give away.

Frequently (and fortunately) interesting exempted applications are proven from time to time, which can serve to illustrate some aspects of the process.

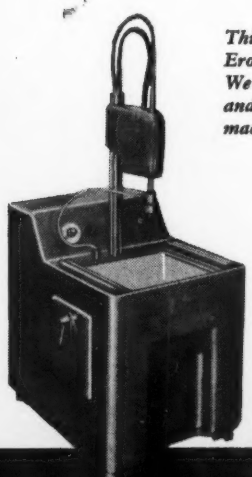
Hole drilling is probably the commonest and most normal of metal-working operations. It poses some problems, however, when the hole required is only 0.008″ diameter, and to be produced in hardened steel, and through a ball bearing at that! Spark machining solved this "insoluble" problem for The Sperry Gyroscope Co.

This press tool die for piercing motor-car radiator top tank covers, illustrates the effectiveness of the process for multi-impression work. A total of 114 slots, each $\frac{5}{8}$″ long by $\frac{1}{10}$″ wide and $\frac{5}{8}$″ deep were pierced in hardened tool steel in less than 24 hours machine time. It was produced on the small Wickman Erodomatic with only intermittent inspection by the operator during the erosion process.

Once set-up and erosion begun, the Wickman Erodomatic operates automatically and continuously until the operation is finished.

These are just two of the many ways in which the spark-machining process is cutting costs and achieving the impossible.

Let us tell you more about the process. We have published a booklet which describes it, and some of the more interesting applications we have engineered. Ask us to send you a copy.



This is the type W/SM Erodomatic Machine. We also make a larger and even more versatile machine, Type W/UV.

WICKMAN Wickman **LIMITED**

MACHINE TOOL DIVISION, BANNER LANE, COVENTRY

Telephone: Tile Hill 66271

472 ER.

Felt washers and felt seals? Felt for anti-vibration bases, for buffing rollers, cushionings and filters? Those are **some** of the ways you can use Bury Felts. They can be die-cut, chiselled, punched, machined, and even ground. Bury Felts are felts made specially for industry; many types and textures to meet your needs exactly.

Versatile stuff– **BURY FELT**

Send your enquiries to:

BURY FELT MANUFACTURING COMPANY LIMITED, P.O. BOX 14, HUDCAR MILLS, BURY, LANCASHIRE

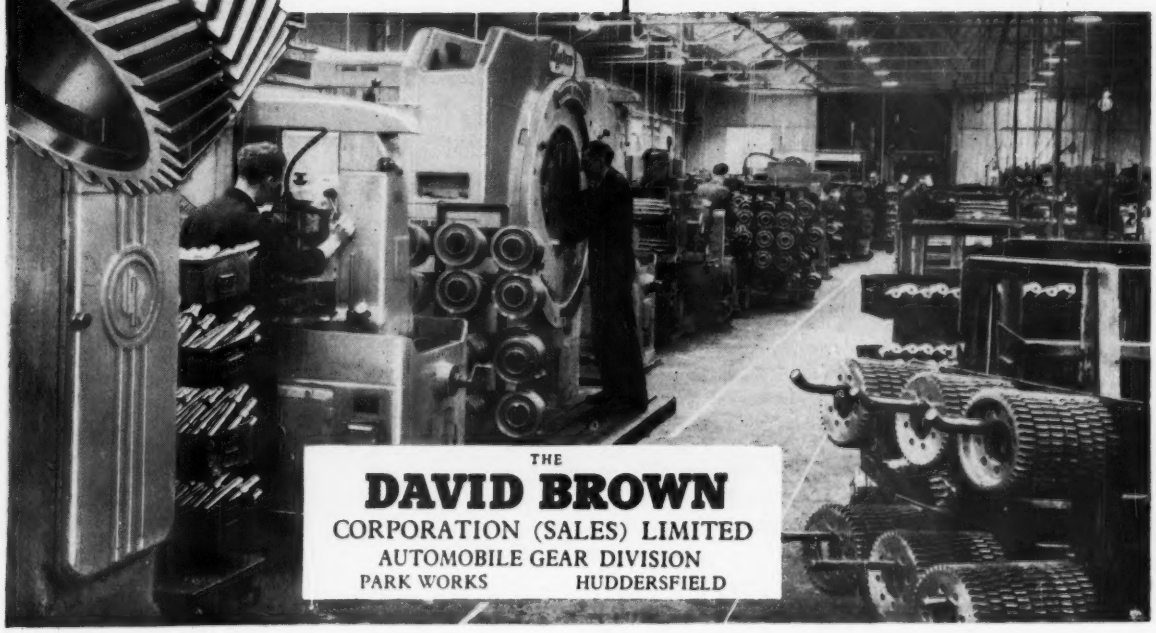
Phone: **BURY 2262 (6 lines)**

London Office: 3 SNOW HILL, E.C.1 · *Phone:* CENtral 4448

SPUR, SINGLE OR DOUBLE HELICAL GEARS OF PRECISION AND PERFORMANCE.

For every type and size of automobile transmission in either small or large quantities specify

"GEARS BY DAVID BROWN"



THE
DAVID BROWN
CORPORATION (SALES) LIMITED
AUTOMOBILE GEAR DIVISION
PARK WORKS HUDDERSFIELD

what is it?

ALUMINIUM CORED SOLDER—

incorporating a non-corrosive flux. It is used with an ordinary soldering iron in the same manner as conventional rosin cored solders and ensures excellent joints without the use of expensive oxide-removing appliances. It is one of a new group of Enthoven products of outstanding interest to all industries in which the soldering of aluminium plays an important part.

To manufacturers of electric and electronic equipment it is the solution of a familiar and stubborn problem—the satisfactory soldering of aluminium to aluminium, or aluminium to copper, tinned copper, tinned and silver-plated brass and other metals.

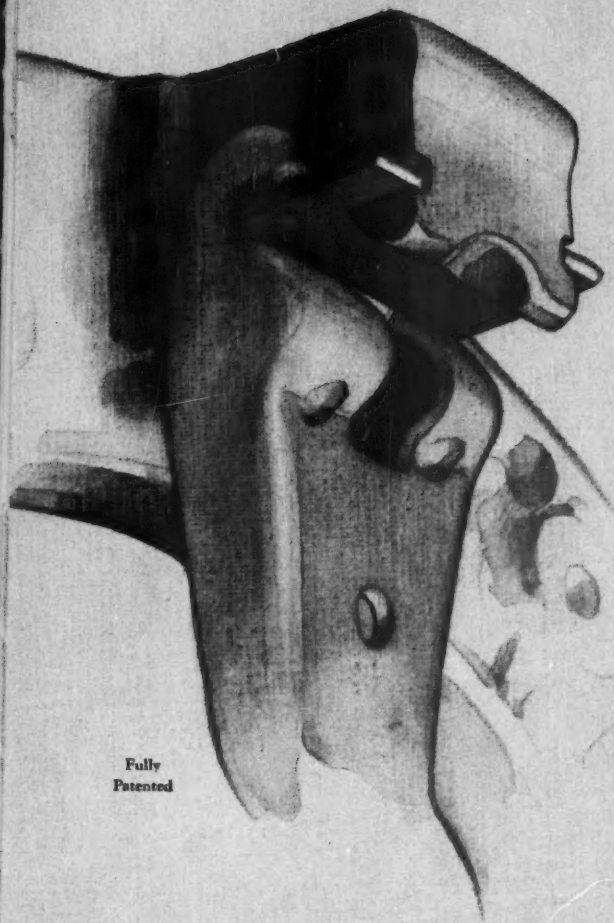
ENTHOVEN SOLDER PRODUCTS

ENTHOVEN PRODUCTS FOR SOLDERING ALUMINIUM

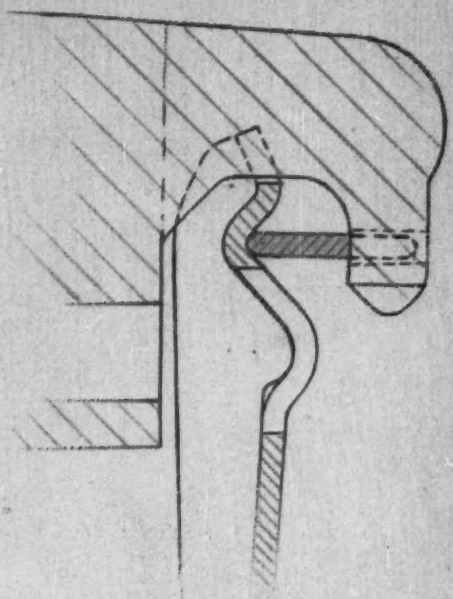
1. ENTHOVEN ALUMINIUM CORED SOLDER—*a unique product specially designed for use in the electrical, electronic and allied industries.*
2. ALUMINIUM SOLDERS & LIQUID FLUX—for dip-soldering and dip-tinning.
3. ALUMINIUM SOLDERS & PASTE FLUX—for general hand soldering and tinning operations.

For further information on these products and their applications, please write for our technical publication "T.P.2".

ENTHOVEN SOLDERS LTD., DOMINION BUILDINGS, SOUTH PLACE, LONDON, E.C.2 MONarch 0391



Fully Patented



Features that have built success

THE RELEASE STRUTS

In many clutches before the days of Borg & Beck, heavy operating or release forces operated through 'scrubbing' contacts in which a very high degree of hampering friction developed.

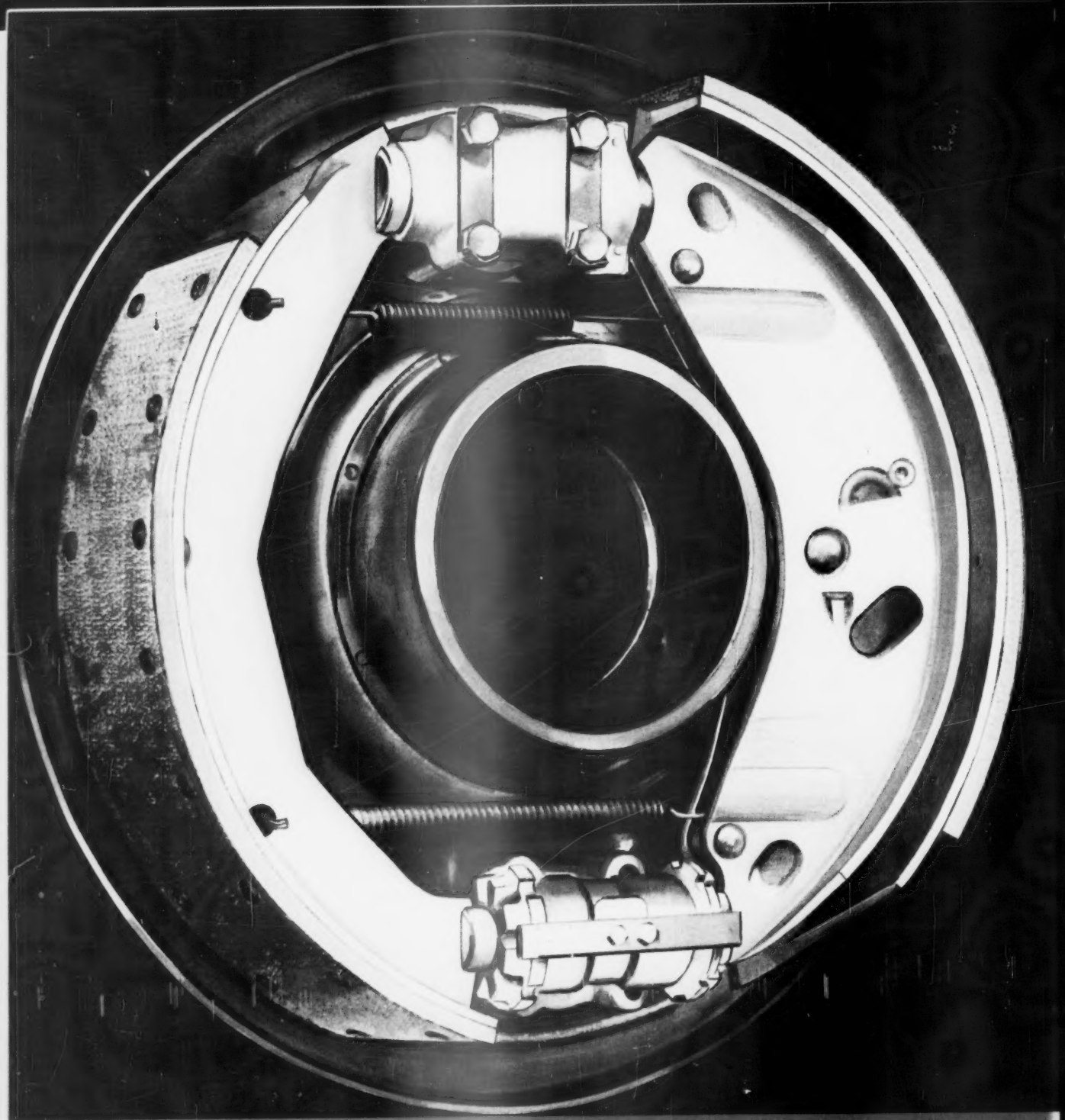
This has been practically abolished by the 'knife-edged' struts of the Borg & Beck release lever system.

The 'knife edges' of these struts are in fact blunt—in order to carry the load, but nevertheless, with their radiused ends, they are in effect compression links pin-jointed at their ends.

BORG & BECK COMPANY LTD., LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

BORG & BECK

REGD. TRADE MARK: BORG & BECK



Brakes for the medium-weight truck

These brakes, 16 in. by 3½ in. rear and 16 in. by 2½ in. front, give an excellent combination for vehicles up to 5-6 tons pay load.

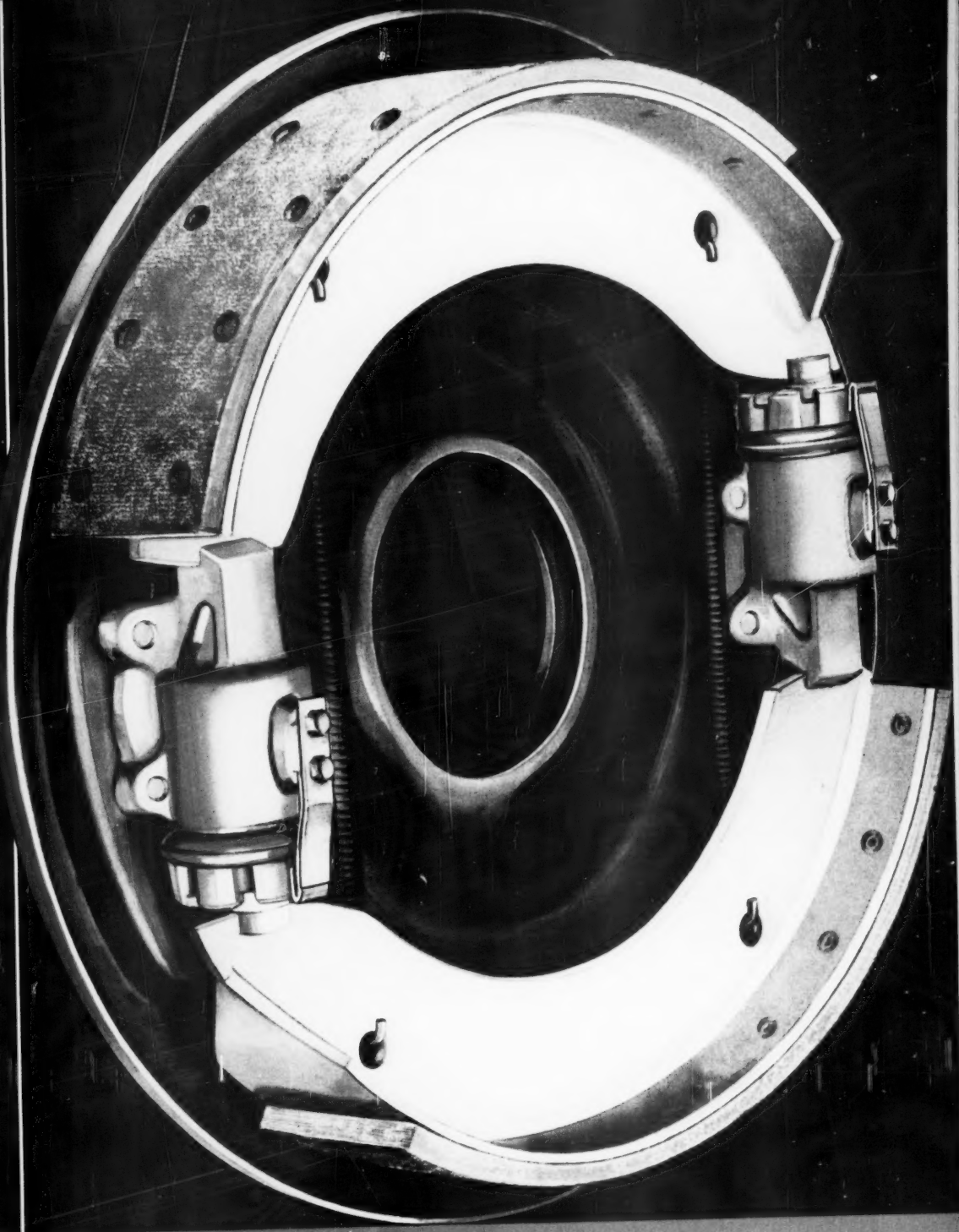
The rear brake has an important new feature in the shoe arrangement, giving a greatly-improved hill-holding quality in reverse with the hand brake. This has been achieved without alteration to the expander cylinder or the hand brake.

The two-leading shoe front brake equalizes the wear on the brake linings, and it has excellent stability.

Both the rear and the front brakes have simple adjustment.

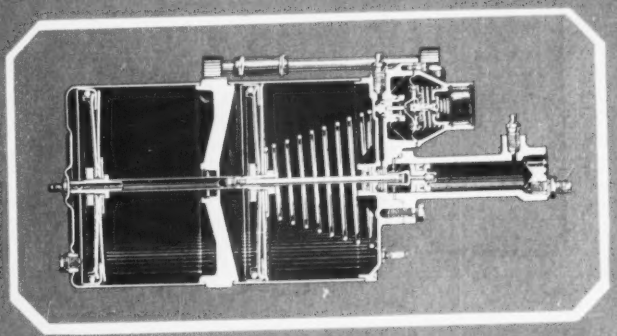
AUTOMOTIVE PRODUCTS COMPANY LIMITED · LEAMINGTON SPA · WARWICKSHIRE

LOCKHEED



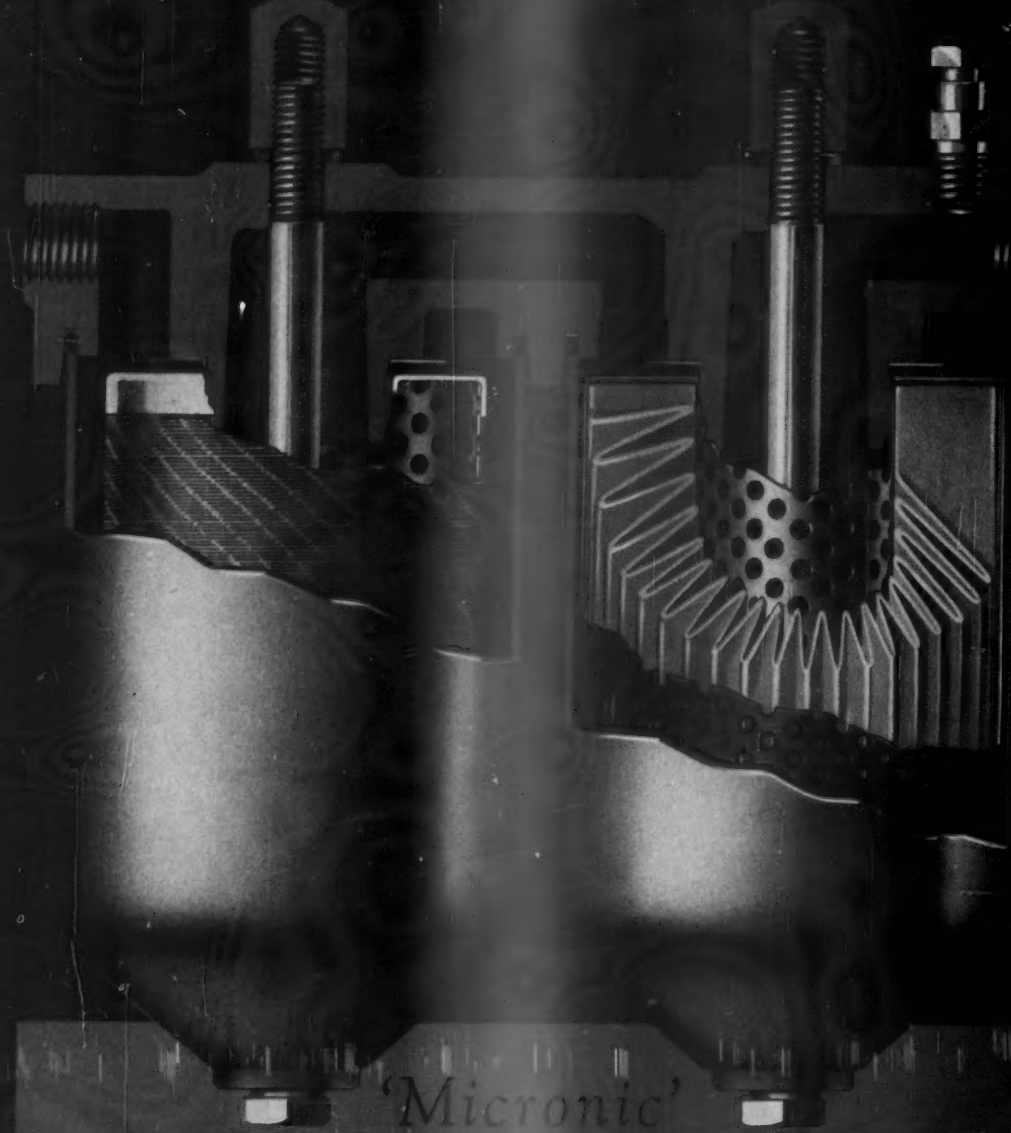
The 'HYDROVAC'

The double Hydrovac illustrated has twice the vacuum effort, due to the two pistons, compared with the well-known single Hydrovac. It is the simplest form of servo for petrol-engined vehicles, and the type illustrated is suitable for operating the brakes described on the opposite page.



Lockheed & Hydrovac are Registered Trade Marks

TWO STAGE



'Micronic' DIESEL FUEL FILTERS

This filter, for the protection of modern high-speed injection equipment, embodies two stages of filtration.

As shown above, the left-hand element is of the Purolator metal edge type, which removes all large dirt particles. This is easily cleaned by swilling in clean fuel or paraffin. The right-hand element is the Purolator 'Micronic' type, having a very large filtration area of specially impregnated paper of controlled texture. This provides the extremely fine filtration required. When renewal of the 'Micronic' element finally becomes necessary, the filter bowl is easily removed by undoing the centre nut; the connections need not be disturbed. Two standard models of this type are available for maximum flow rates of 6 and 10 G.P.H. Two-stage filters are also available having 'Micronic' elements in both stages. This arrangement prevents foreign matter being introduced into the system when replacing the first stage element, and is recommended where unskilled labour is employed.

AUTOMOTIVE PRODUCTS COMPANY LIMITED, LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

PUROLATOR

Registered Trade Marks relating to 'Micronic'

'MICRONIC' LUBRICATING OIL, FUEL AND AIR FILTERS

ASQUITH

MULTI-WAY UNIT TYPE MACHINES

for heavy duty, high-output production

Asquith Multi-way Machines have been supplied for high production of a wide variety of components in many industries and the illustrations above are two typical examples.

The Asquith range of Unit Heads, from ½ h.p. upwards, forms the basis on which these special-purpose machines are planned.

If therefore you have a component which is required in quantity that is being produced on separate machines it may prove worthwhile investigating the possibility of machining it on an Asquith Unit Head type with savings in cost and time.

WILLIAM ASQUITH LTD.
HALIFAX · ENGLAND

Sales & Service for . . . **DRUMMOND-ASQUITH** *. . . the British Isles*

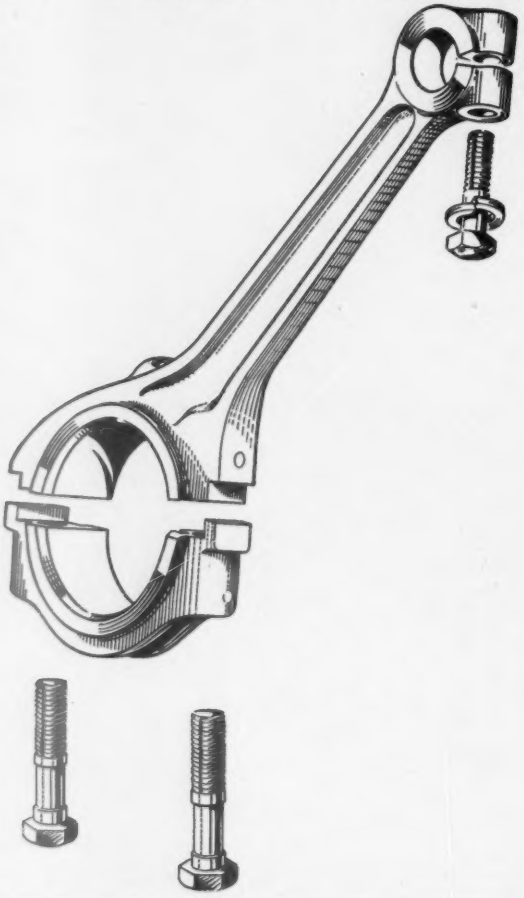
DRUMMOND-ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW ST., BIRMINGHAM

'Phone : Midland 3431 (7 lines) 'Grams : Maxishape, B'ham. Also at LONDON : Phone : Trafalgar 7224 (5 lines) and GLASGOW : 'Phone : Central 3411

A 191

PARK GATE

QUALITY STEELS FOR DROP FORGINGS



1823 EXPERIENTIA DOCET 1957

black bars

for

connecting rods

THE PARK GATE IRON & STEEL COMPANY LIMITED ROTHERHAM

TELEPHONE: ROTHERHAM 2141 (10 lines) TELEGRAMS: YORKSHIRE, PARKGATE, YORKS

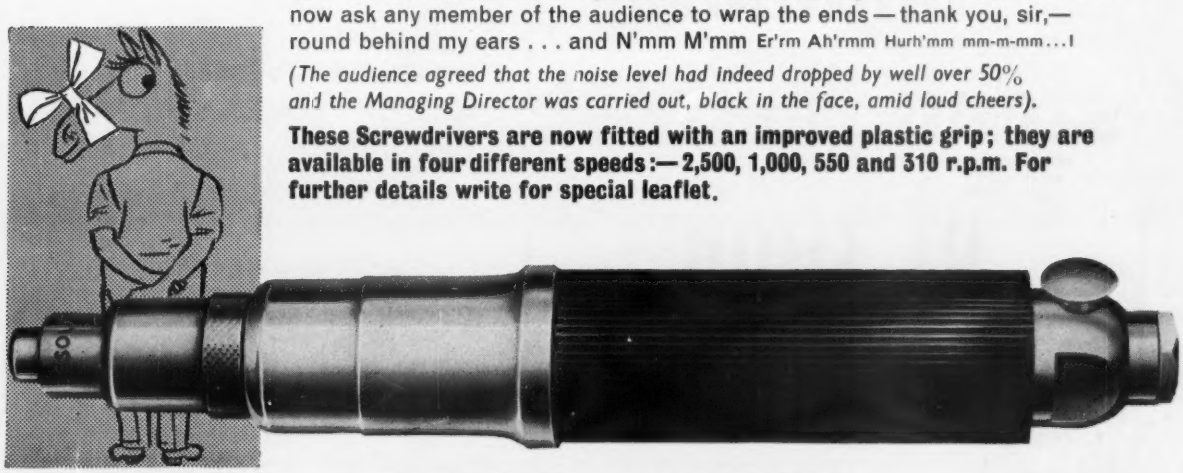
Silence IS GOLDEN

Never satisfied! Always improving! A steady progress towards perfection—*burbled the Managing Director in his most self-satisfied voice.*
Take Pneumatic Screwdrivers. Efficient, you say—but perhaps a trifle noisy for the assembly line.

Sir, you are living in the past. This Little Horse here *(" this 'ere Little Horse, if you please " muttered the Little Horse in question)* operates a screwdriver. Note that we have fitted him with a kind of gag or muffler, thus reducing the operating noise level by more than 50%. The principle is really very simple—as I will now demonstrate. I place this muffler over my mouth . . . so . . . I will now ask any member of the audience to wrap the ends—thank you, sir,—round behind my ears . . . and N'mm M'mm Er'rm Ah'rmm Hurh'mm mm-m-mm . . . !

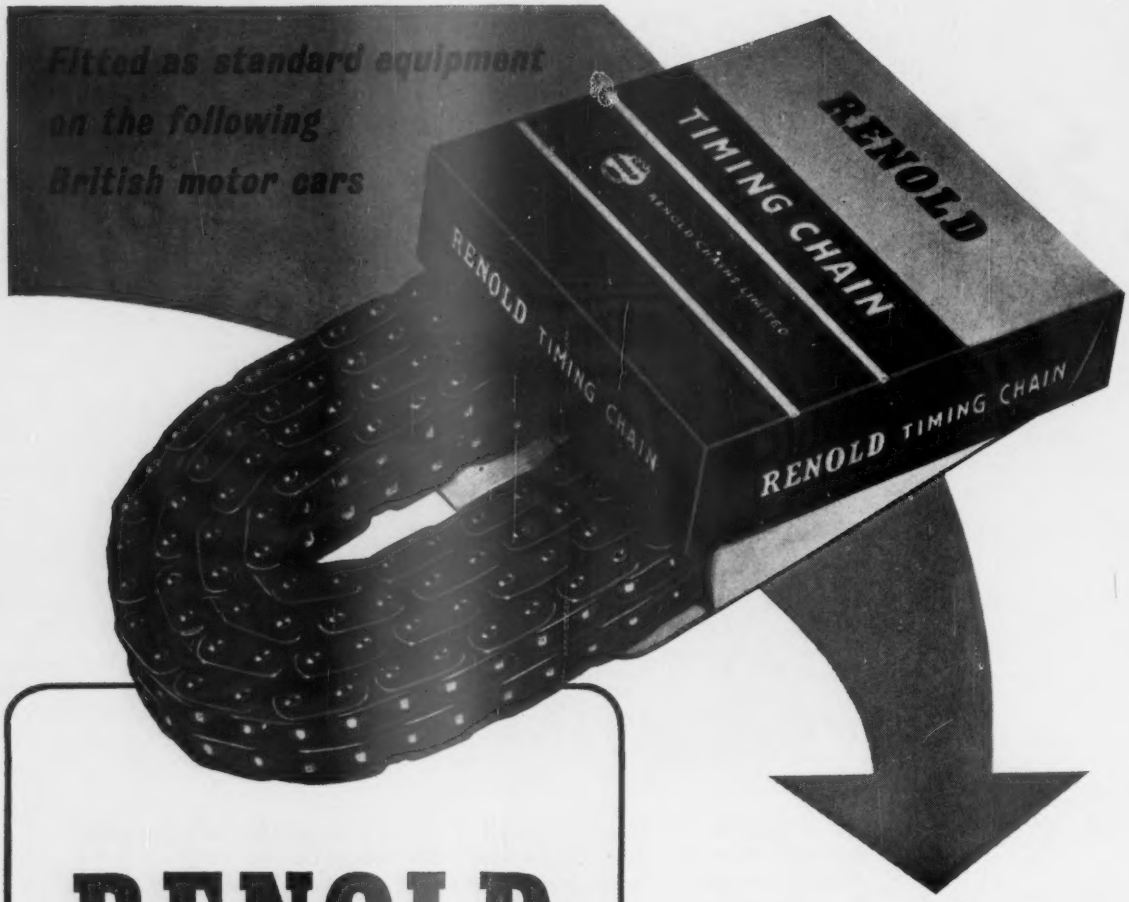
(The audience agreed that the noise level had indeed dropped by well over 50% and the Managing Director was carried out, black in the face, amid loud cheers).

These Screwdrivers are now fitted with an improved plastic grip; they are available in four different speeds:—2,500, 1,000, 550 and 310 r.p.m. For further details write for special leaflet.



THE NEW **DESOUTTER**
silent screwdriver

Desoutter Brothers Limited, The Hyde, Hendon, London, N.W.9. *Telephone: Colindale 6346 (5 lines).* *Telegrams: Despnuco, Hyde, London*
CRC281



RENOLD chains stand the test of time

A.C. · ALLARD · ALVIS
ARMSTRONG SIDDELEY
ASTON-MARTIN · AUSTIN
AUSTIN-HEALEY · BRISTOL
CITROEN · CONNAUGHT
COOPER · DAIMLER · DELLOW
FORD · FRAZER-NASH · H.R.G.
HILLMAN · HUMBER · JAGUAR
JENSEN · LAGONDA · LOTUS
M.G. · METROPOLITAN · MORRIS
MORGAN · RILEY · ROVER
SINGER · STANDARD · SUNBEAM
TRIUMPH · TURNER · WOLSELEY
VAUXHALL

RENOLD—*the FIRST name in precision chain*

RENOLD CHAINS LIMITED · MANCHESTER

TWO DRIVES

ONE CLUTCH

The new Laycock-Spicer Dual Drive Clutch has been developed for Tractor use. It assures farmers of increased safety and efficiency. They can operate such machines as the baler, mower or harvester continuously, regardless of tractor starts and stops.

Since the left foot of the operator gives complete control over both tractor motion and power-take-off, both hands are entirely free for steering, gear changes, and other requirements.

Ask Laycock for the fullest details of this new advance in power transmission.

Laycock-Spicer Dual Drive Clutch

LAYCOCK ENGINEERING LTD.

VICTORIA WORKS—MILLHOUSES—SHEFFIELD 8

648 new bearings

Equivalent and interchangeable with bearings of American type and manufacture.

Our catalogue MAX/54 giving full details of dimensions, cage, lip, circlip, and full of roller types, arrangements, special features, etc., is available on application.

POLLARD 'MAX-LOAD' ROLLER BEARINGS

The Max-Load illustrated above has a single lipped inner race, an outer race with one circlip and one lip, and a pressed steel cage.

In addition Pollard Bearings manufacture Ball, Roller and Thrust Bearings (Cat. BRT/1053). Solid and Flexible Roller Bearings (Cat. RFX). Transmission Equipment and Plummer Blocks (Cat. TR.27/2). Self-Lube Plummer Blocks (Cat. SL/54). Automobile and Tractor Replacements (Cat. BRM/54). Clutch Withdrawal and Water Pump Spindle Bearings (Cat. CWFP/54).

HEAD OFFICE: FERRYBRIDGE, KNOTTINGLEY, YORKS.
Tele: KNOTTINGLEY 2323 Telex.: 55-242
Telegrams: BALBEARING, FERRYBRIDGE

LONDON OFFICE: 44 HERTFORD STREET, W.1.
Tele: LEGATION 3888. Telex.: 2-3549
Telegrams: BALBEARING, LONDON

CANADIAN POLLARD BEARINGS LTD.,
BOX 424, QUEEN ELIZABETH WEST, OAKVILLE,
ONTARIO, TORONTO.
also 1103-6, BEAVER HALL HILL, MONTREAL.
Tele: UN 6-5774.

B21905

CASE HARDENING FURNACES

Whereas the crab is by nature endowed with a hard shell, many engineering components require special treatment to provide a tough wear resistant surface. Birlec furnaces have been employed in case hardening applications for more than 30 years.

Birlec gas carburising furnaces of the well known batch and continuous types are now supplemented by the Birlec sealed quench unit. Suitable for carburising, carbo-nitriding and clean hardening, these newly developed furnaces provide for direct quenching under atmosphere protection, ensuring a perfectly clean surface. There is a Birlec furnace for every heat treatment process.

BIRLEC

BIRLEC LIMITED

An A.E.I. Company

ERDINGTON · BIRMINGHAM 24

LONDON
SHEFFIELD
GLASGOW
NEWCASTLE-ON-TYNE

SM/B 2952F

all lined up and

with CAPASCO Regd.

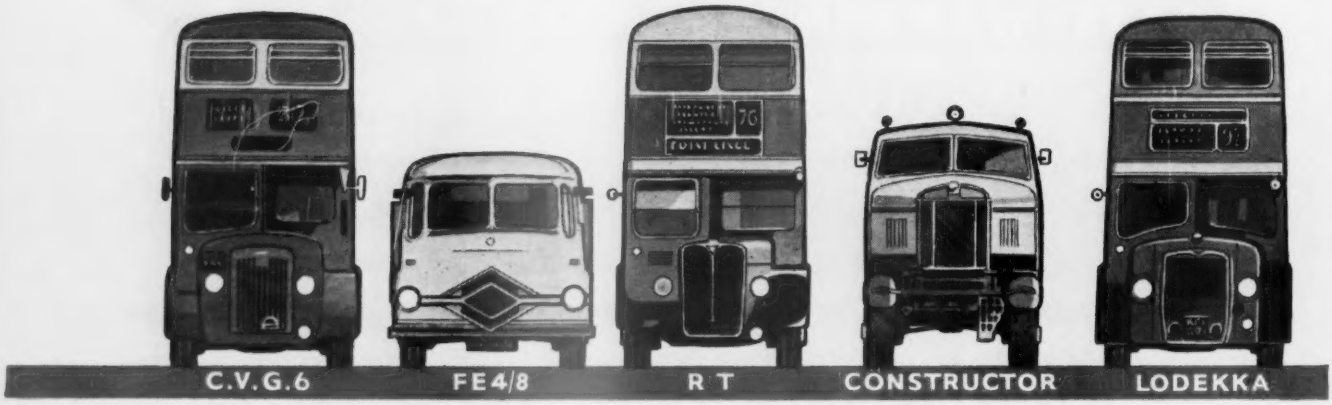
moulded brake

fitted as standard equipment by

A.C.V. LIMITED · ALBION MOTORS LTD

THE AUSTIN MOTOR CO. LTD

BRISTOL COMMERCIAL VEHICLES LTD



THE CAPE ASBESTOS COMPANY LIMITED

and at MANCHESTER: National Buildings, St. Mary's Parsonage, Manchester 3, Tel : Deansgate 6016-7-8; GLASGOW: 217 Bothwell Street, Glasgow, C2, Tel : Central 2175

ready to

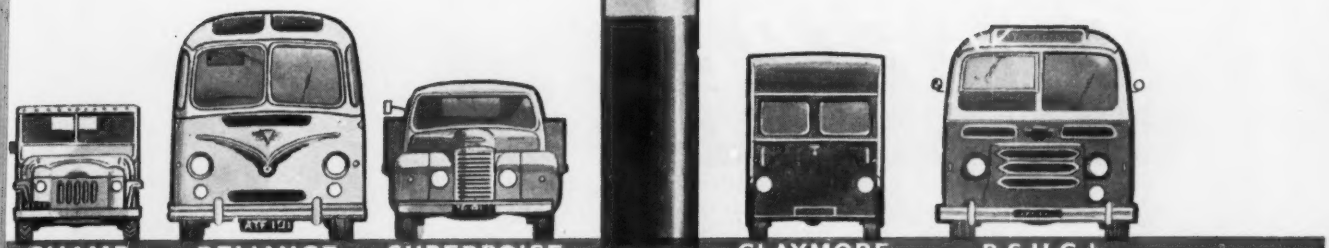
linings

OMMER CARS LTD · FODENS LTD

EYLAND MOTORS LTD · LONDON TRANSPORT

CAMMELL LORRIES LTD

RANSPORT VEHICLES (DAIMLER) LTD



114 & 116 PARK STREET LONDON W.1

Telephone: GROsvenor 6022

CAPE

IRMINGHAM: 11 Waterloo Street, Birmingham 2. Tel: Midland 6565-6-7

TA 9471

THE NEW BRITISH OXYGEN

SAFFIRE

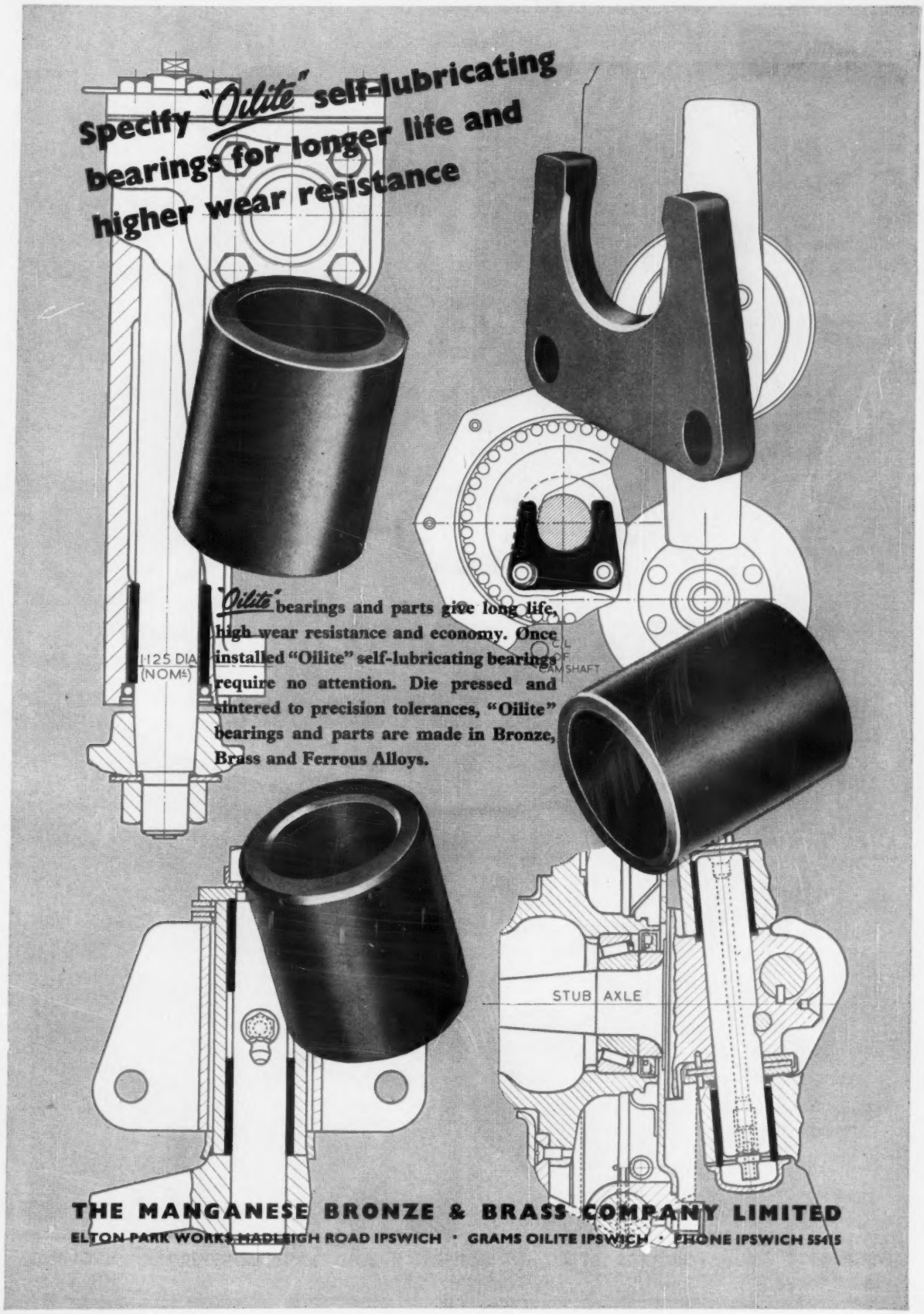
WELDING BLOWPIPE

The most advanced Welding Blowpipe available today. Can be readily adapted for Cutting, Heating and Flame Cleaning.

For full details please write to:

BRITISH OXYGEN

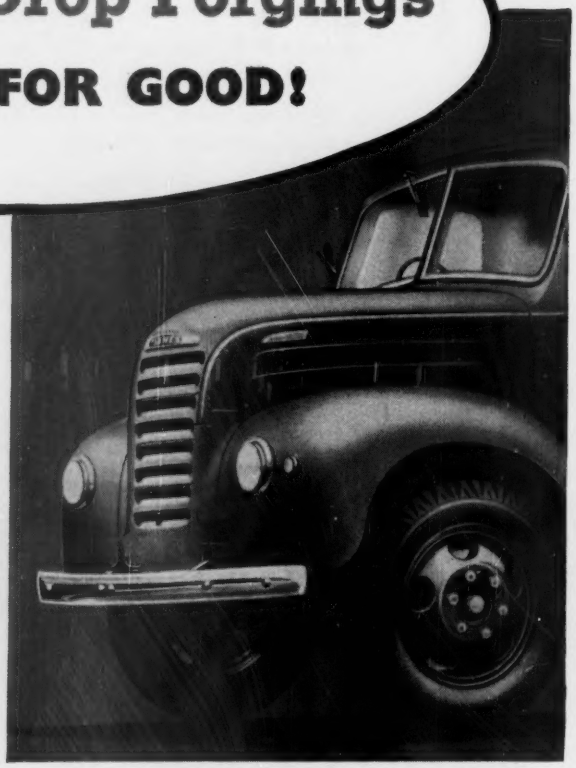
British Oxygen Gases Ltd., Bridgewater House, St. James's, London, S.W.1


Specify "Oilite" self-lubricating bearings for longer life and higher wear resistance
"Oilite" bearings and parts give long life, high wear resistance and economy. Once installed "Oilite" self-lubricating bearings require no attention. Die pressed and sintered to precision tolerances, "Oilite" bearings and parts are made in Bronze, Brass and Ferrous Alloys.
1·125 DIA (NOM.)
STUB AXLE
THE MANGANESE BRONZE & BRASS COMPANY LIMITED
ELTON PARK WORKS HADLEIGH ROAD IPSWICH · GRAMS OILITE IPSWICH · PHONE IPSWICH 55415
P3798

SDF

Smethwick Drop Forgings

...FITTED FOR GOOD!



SMETHWICK DROP FORGINGS LTD. • SMETHWICK AND KIDDERMINSTER • ENGLAND

Plastics mean progress!

COME TO BRITISH PLASTICS International EXHIBITION AND CONVENTION

OLYMPIA · GRAND & NATIONAL HALLS
10-20 JULY

See how the latest advances can be applied to your business

PRODUCTS

EQUIPMENT

MATERIALS

BRITISH PLASTICS EXHIBITION OLYMPIA 10-20 JULY

Visitors to the British Plastics Exhibition will reap a rich reward in new ideas, methods and plans for improved products—extended ranges—enhanced sales appeal—increased production and reduced costs!

This is your opportunity to see the biggest array of plastics products, materials and equipment ever assembled in Britain—covering over 200,000 square feet of floor space in Olympia's Grand and National Halls. A whole world of plastics, with exhibits from every branch of the British industry, and from Belgium, France, Germany, Holland, Italy, Sweden, Switzerland and the U.S.A.

Come and examine the latest plastics machinery (much of it in action); discuss your problems with experts; see how plastics can mean progress in *your* business—at this great exhibition organized by BRITISH PLASTICS, the journal that speaks for the industry.

At the British Plastics Convention, held simultaneously, important papers will be read and discussed in open forum under the general headings of: polythenes, vinyls, glass-reinforced plastics, extrusion and moulding.

A whole world of plastics on view

Exhibition organized every second year by BRITISH PLASTICS, an ILIFFE Journal

Plan your visit ahead Post this today!

Please send me the 1957 Exhibition brochure, free season ticket, etc.

NAME ..... DATE .....

FIRM .....

ADDRESS .....

.....

31B TO: EXHIBITION MANAGER, BRITISH PLASTICS, DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1.

ARCHDALE for AUTOMATION

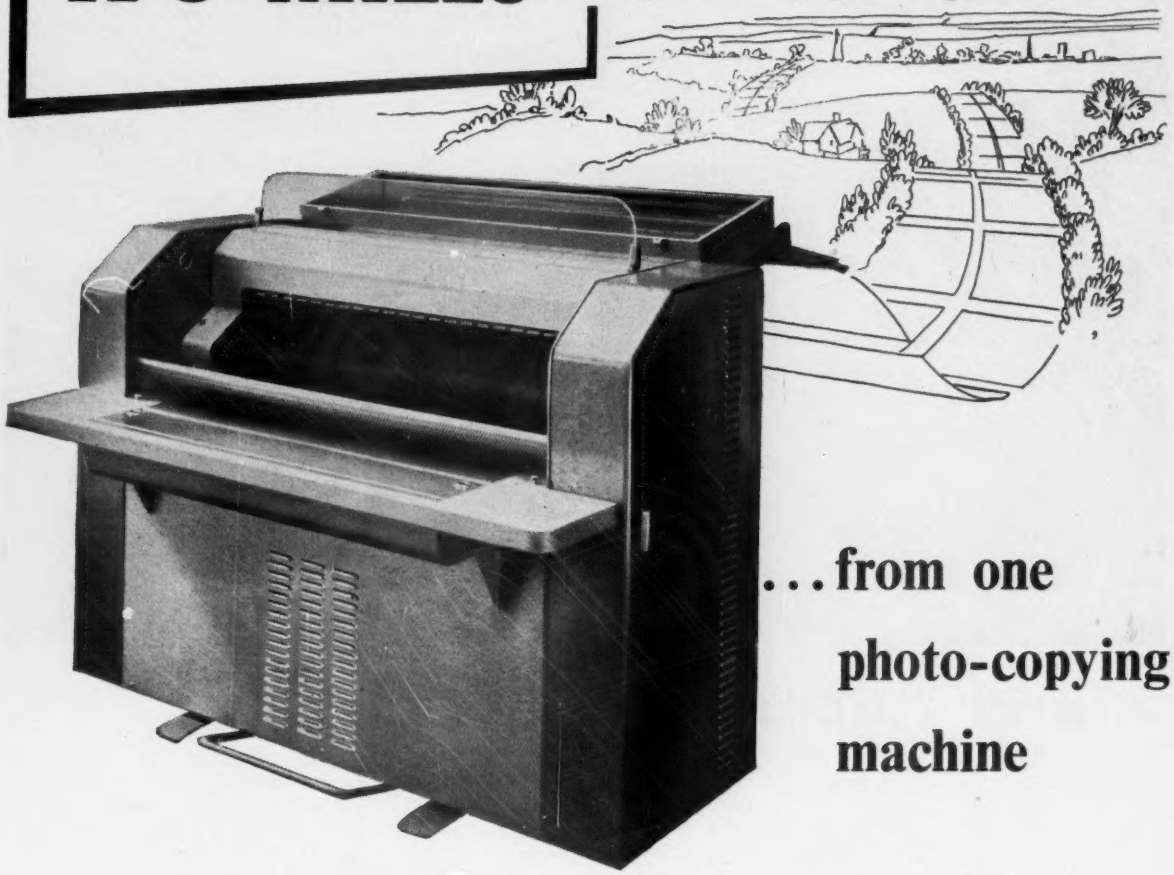
FIFTEEN STATION 'UNIMATIC' TRANSFER MACHINE, milling, drilling, rough and finish boring, reaming, tapping and spot facing steering boxes at Burmans, Ltd., Birmingham.

JAMES ARCHDALE & CO. LTD., LEDSAM ST., BIRMINGHAM, 16.

Telephone: EDGbaston 2276 (3 lines) Telegrams: ARCHDALE, BIRMINGHAM.

Sole Selling Agents: ALFRED HERBERT LTD., COVENTRY.

175 MILES *of prints per year . . .*



. . . from one photo-copying machine

175 miles of prints a year is the output reported by one regular user of an Azoflex Model 46/35—and that's the sort of output that any busy drawing office can expect. The AZOFLEX photo-printing process combines several unique features. It's the *only* daylight reflex copying process. It's the *only* process to apply a measured quantity of developer irrespective of running speed, thus ensuring optimum quality. It avoids the use of dangerous chemicals and there are no unpleasant fumes. Operation is quiet and free from vibration. Exposing, developing and print delivery are all synchronised to ensure an even flow of finished work at all speeds.

AZOFLEX MODEL 46/35 combined synchronised printer and developer. Capacity : cut sheets and rolls up to 42 in. wide. Printing speed: up to 30 ft. per minute. Dimensions : Height 58 in. Depth 60 in. Width 72 in. Weight 1,100 lb. Price £1,555 (including delivery and installation in the U.K.).

ILFORD *Azoflex*

Enquiries to : Ilford Limited, Azoflex Dept. AZ11B
104 High Holborn, London, W.C.1. Telephone : HOLborn 3401

PHOTO-PRINTING MACHINES AND MATERIALS

Switch from this

to this

and step up production . . .

For working within close limits, an Anglepoise is simply indispensable. However good a worker and his eyes may be, he must see the job. This applies in all fine work, drilling, assembling, etc., where instantly adjustable close-to-the-job lighting is a sheer necessity.

Anglepoise throws a clear, concentrated light right on and into the work, not in the operator's eyes, follows the job from any position or angle, degree by degree, at a finger-touch and 'stays put' in any required position—and out of the way when not needed. It needs only a low-powered bulb for high-class results—a big saving on the lighting bill (it can be supplied with a small shade for low voltage systems). Why not learn more about this fine lamp by sending for Booklet A?

TERRY Anglepoise LAMP
Regd.

Sole Makers: **HERBERT TERRY & SONS LTD · REDDITCH · WORCESTERSHIRE**

*** A SUGGESTION FOR MACHINE MANUFACTURERS:–**

Why not fit your products with Anglepoise? We will submit samples on approval.

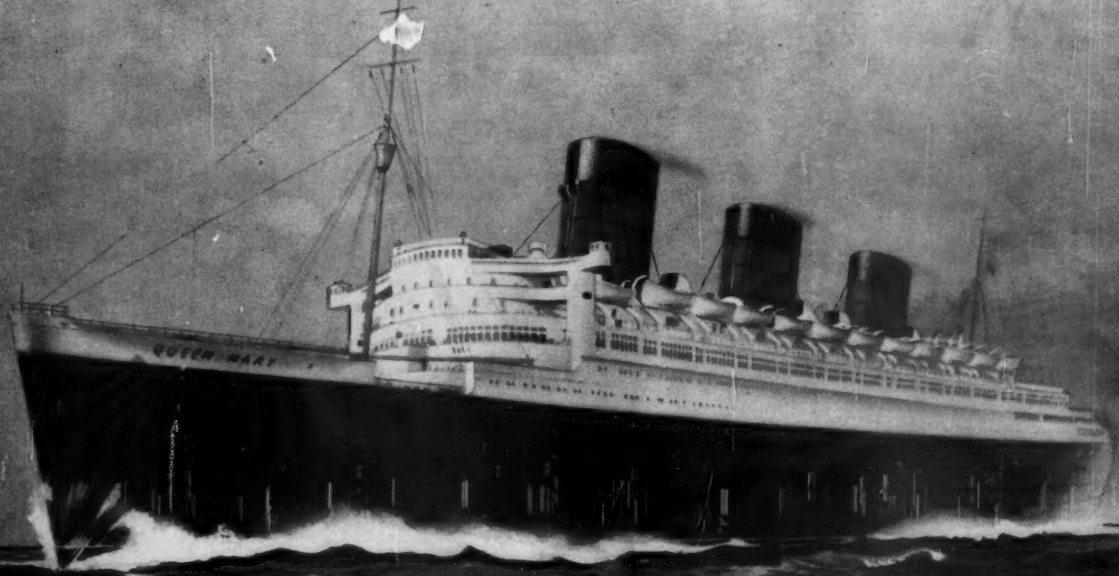
Some of the alternative bases for all models

HT30

OAKENSTRONG
OAKENCORK

OIL and PETROL

GASKET MATERIALS



REGISTERED

TRADE MARK

IMPORTERS OF MATERIAL
IN SHEET FOR GT. BRITAIN

A. NORDBERG LTD

QUEEN VICTORIA ST.
LONDON E.C.4

TEL: CENTRAL

FOREIGN & COLONIAL
ENQUIRES TO

H. JACKSON LTD

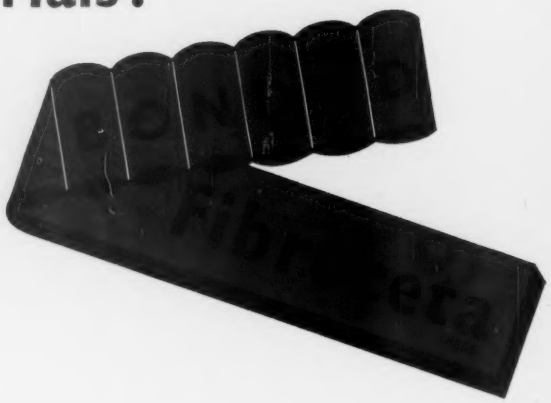
OAKENCLOUGH, GARSTANG,
Nr. PRESTON, LANCS.

TEL: GARSTANG.

INVERNESS GROUP

Have you a problem in thermal or acoustic insulation? diathermal welding? wadding? padding? filling materials?

probably

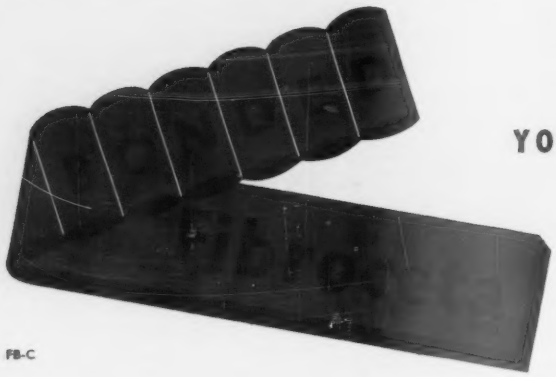


holds the answer . . . .

BONDED 'FIBROCETA'—a new raw material. A resilient wadding of extraordinary versatility . . . taking many physical forms, and with many desirable qualities—lightness, cheapness, and extreme ease of handling among them.

BONDED 'FIBROCETA' CAN BE r.f. w|e|l|d|e|d

Under continuous development, Bonded 'Fibroceta' can almost certainly be of real value to your industry. Bring us your problems: we will gladly co-operate with you to find a better answer.



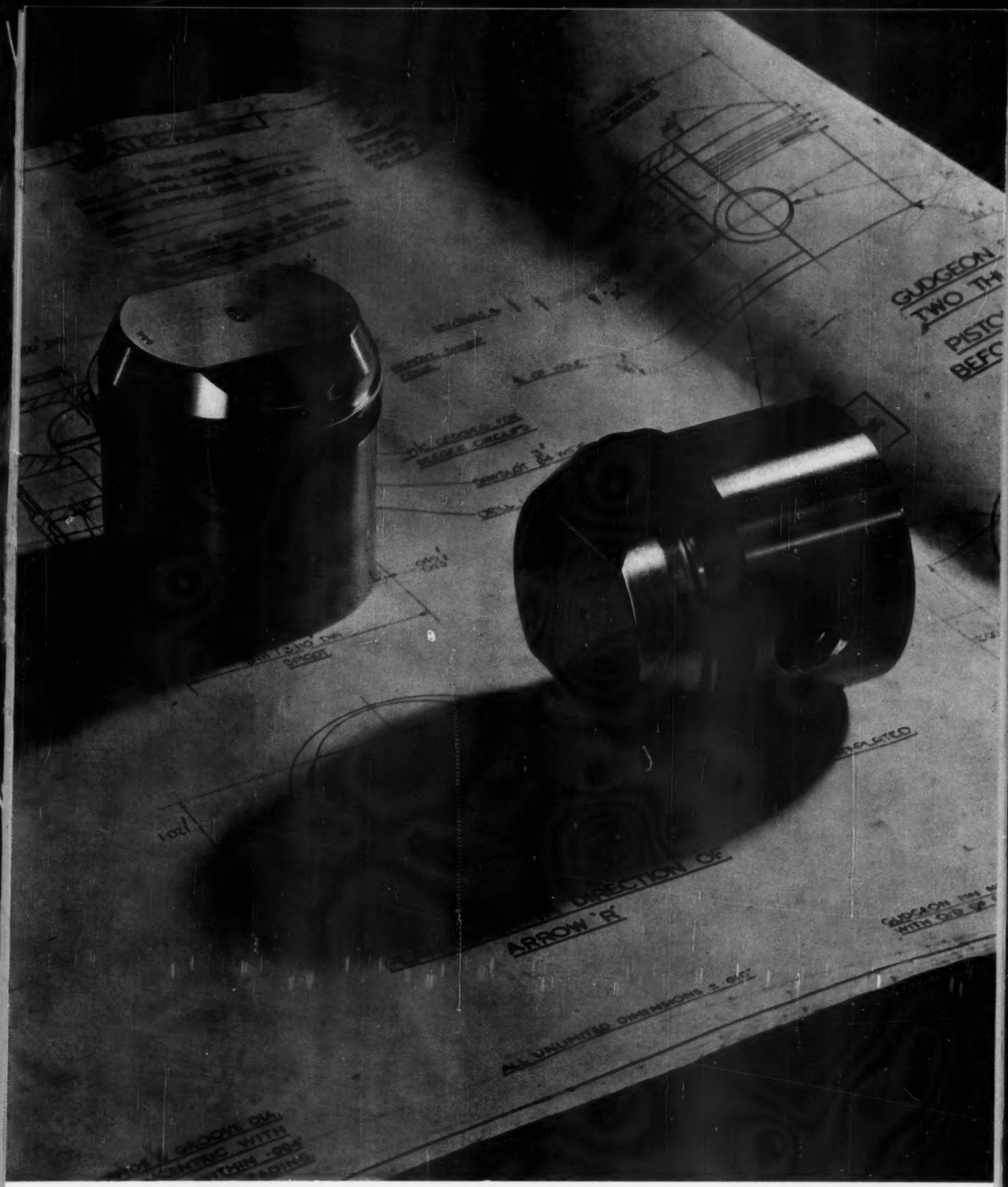
FB-C

'Fibroceta' Courtaulds Acetate Staple

YOUR ENQUIRIES ARE WELCOMED AT

Courtaulds
Limited

ACETATE DIVISION, FOLESHILL ROAD, COVENTRY.
TELEPHONE: COVENTRY 88771.



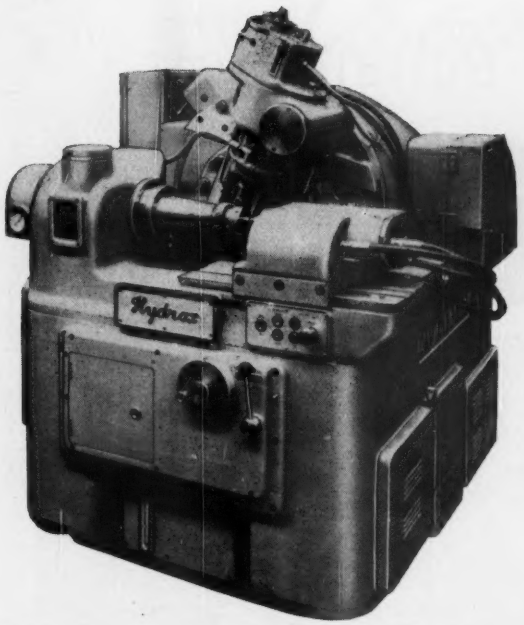
TRADE MARK

PISTONS for all the best engines

THE BRITISH PISTON RING CO., LTD., COVENTRY, ENGLAND

GACO
'O' RINGS
GEORGE ANGUS & Co LTD
OIL SEAL DIVISION
COAST ROAD, WALLSEND-ON-TYNE.
GALO

GEAR QUIZ ①



Q *Your No. 7 Hydrax Hobbing Machine looks good — what is its production rate for a 32 teeth helical gear, 12 D.P., 36° 58′ helix angle, ⅜″ face in E.N. 24 material?*

A **Two gears would be hobbed together using hand loading with fully automatic cycle. The floor to floor time per gear would be 55 secs. — 480 gears in an 8-hour shift. You benefit by the Hydrax technique and the finish would be suitable for shaving or grinding.**

WRITE ***NOW*** *FOR LEAFLET M. 104.4*

Q *This looks an extremely robust machine — what will it do?*

A **The PH30 Production Hobber, set for automatic cycle, will, to select a typical example, cut a 112 tooth helical gear, 5 D.P., 20° helix angle, 2″ face in E.N. 8 in 58 mins. floor to floor time. Three gears would be cut per setting and single roughing and finishing cuts only would be required.**

WRITE ***NOW*** *FOR LEAFLET M. 107.1*

Please address your replies to Gear Quiz

Q *We've heard about the tremendous production rate of this machine — what will it give us for our 32 teeth helical gears, 12 D.P., 36° 58′ helix angle, ⅜″ face in E.N. 24?*

A **Using the David Brown Oblique Traverse method, the S6H Shaving Machine will give a floor to floor time of only 32 secs. or 800 gears per 8-hour shift. The fully automatic cycle and changing would be used with hand loading.**

WRITE ***NOW*** *FOR LEAFLET M. 103.9*

THE
DAVID BROWN
CORPORATION (SALES) LIMITED
MACHINE TOOL DIVISION
BRITANNIA WORKS SHERBORNE STREET
MANCHESTER 3

structural plastics in body building?

ask Artrite!

The Artrite range of polyester resins and compounds includes the right material for every purpose . . . excellent weather resistance . . . light and heat stable . . . fire retardant . . . good water and chemical resistance.

Fully formulated polyester compounds for lay-up moulding . . . the Artrite G.C. series for applying the gel-coat . . . the Artrite L.U. series for laying up glass fibres.

Comprehensive series of polyester resins—the Artrite P.E. series. Glass fibre filled moulding materials—the Artrite A.G. and P.G. series.

Enterprising designers are turning to glass fibre reinforced plastics for an increasing range of large and small components. Why not make use of Artrite's expert staff and fully equipped laboratories for the best advice on materials and fabrication techniques.

You will find us at Stand No. C5

AR

ARTRITE resins limited

Kingsway Chambers, 44-46 Kingsway, London, W.C.2 HOLborn 3138.

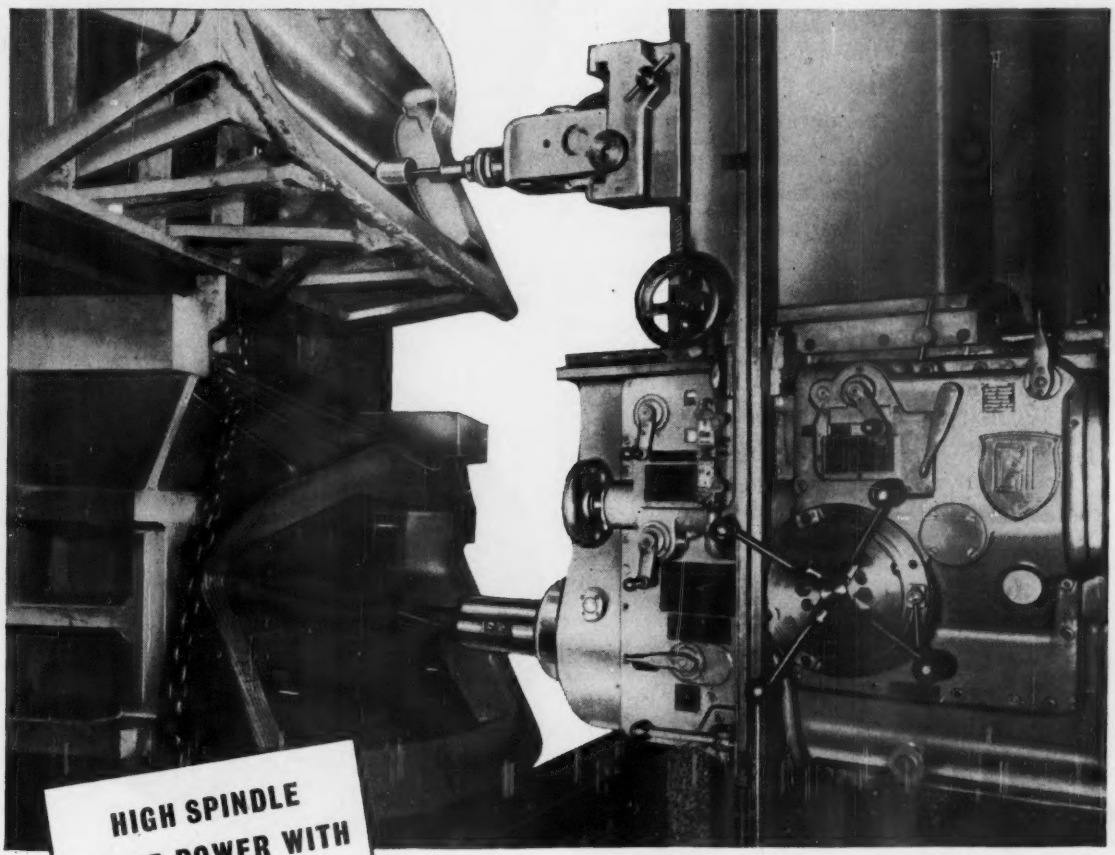
The right materials for every purpose — the right advice on every application

GIDDINGS and LEWIS MACHINE TOOL CO.

Co-operation sets

BRITISH THOMSON-HOUSTON CO. LTD.

Entirely *NEW* Standards *in* HEAVY CONTOURING & DIE MILLING



HIGH SPINDLE HORSE POWER WITH ABSOLUTELY STEPLESS TRACING ENSURES RAPID MACHINING WITH EXTREME ACCURACY.

The only machine on the market which is both a high-precision, *high-powered* milling, boring, drilling machine and also a most versatile duplicating machine capable of carrying out all the operations necessary for die milling and 360° profile work *with a speed and accuracy unattainable by any other system.*

ROCKWELL MACHINE TOOL CO. LTD.

WELSH HARP, EDGWARE ROAD, LONDON, N.W.2. TELEPHONE: GLADSTONE 0033

ALSO AT · BIRMINGHAM – TELEPHONE SPRINGFIELD 1134/5 · STOCKPORT – TELEPHONE STOCKPORT 5241 · GLASGOW – TELEPHONE MERRYLEE 2822

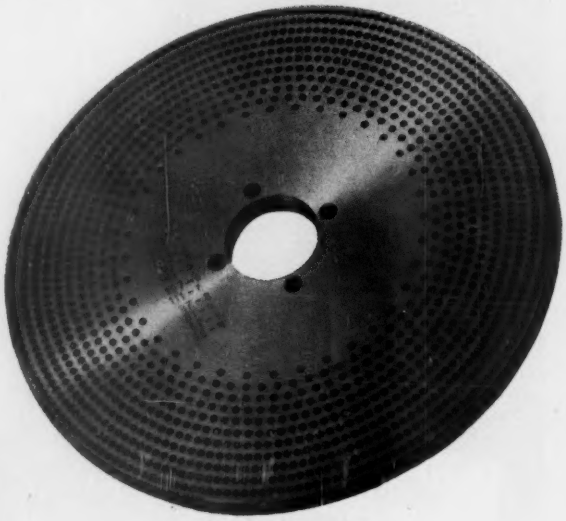
"Such satisfactory results have never been obtained before"
say CUNLIFFE & CROOM *of . . .*

HARPER CASTINGS

Of this precision dividing-head plate for milling machines Cunliffe & Croom say, "We find that by using Harper Castings we get a plate with a good clean surface and, equally important, consistent hardness. Each casting has to be drilled with about 2,000 small holes which must have a clean edge and a firm wall between the holes which are extremely close together."

Harper quality covers grey iron and Meehanite *castings, also metal pressings, machining, enamelling and other finishes and sub-assembly work.*

Un-machined casting of dividing-head plate.



Casting machined and drilled.

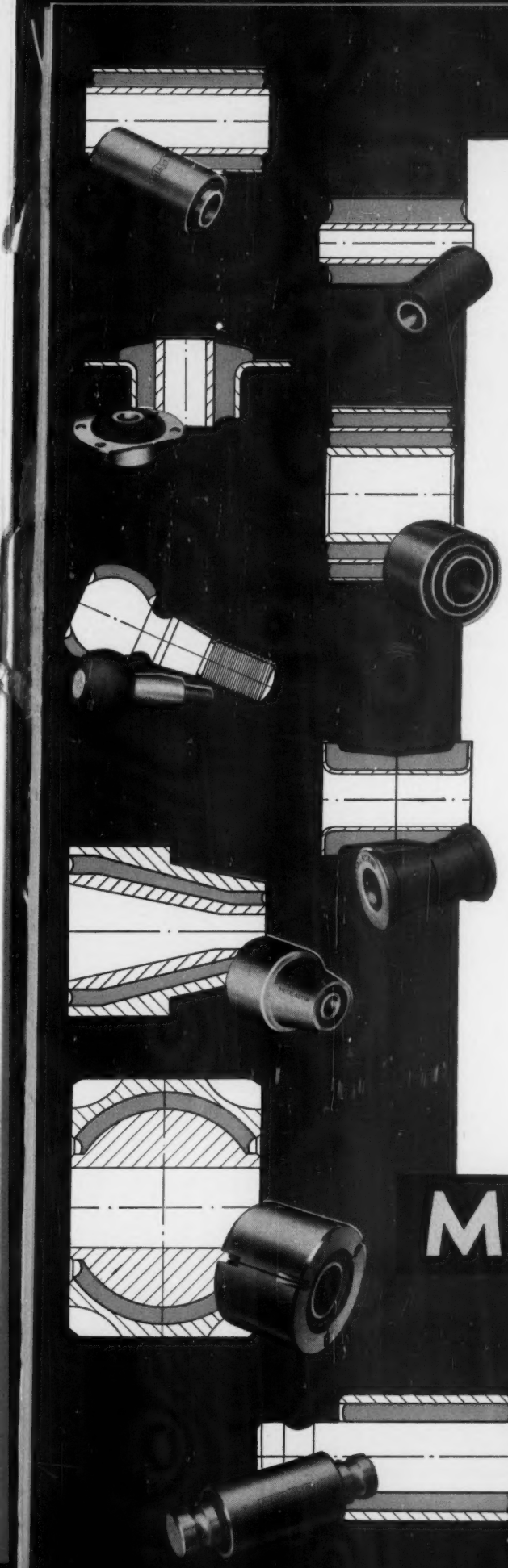
Left: Finished Casting in position on milling machine.

JOHN HARPER & CO. LTD. **JOHN HARPER** (MEEHANITE) **LTD.**
ALBION WORKS Phone: WILLENHALL 124 (5 lines) Grams: HARPERS, WILLENHALL **WILLENHALL**

CASTINGS WITH THE HARPER SKIN

LONDON OFFICE: SEAFORTH PLACE, 57, BUCKINGHAM GATE, LONDON S.W.1 Tel.: TATE GALLERY 0286
MANCHESTER OFFICE: c/o B. J. Brown & Partners Ltd. 248/9 Royal Exchange, Manchester 2

H 615



FLEXIBLE BEARINGS

These bearings are made in a wide range of types and permit oscillatory movements by the deflection of the rubber in shear, thus avoiding the need for lubrication.

The chief types of Metalastik bearings are the following:—

1. **METALASTIK U.D.** (Ultra-Duty) **BUSHES** are rubber-bonded to both inner and outer sleeves, and pre-compressed to give the optimum fatigue life. They can also be used as springs, loaded torsionally, axially or radially and can be formed to give different characteristics in different directions.

2. **METALASTIK I.S.** (Inner Sleeve) **BUSHES.** In this bush only the inner sleeve is bonded to the rubber, the rubber being pre-compressed in assembling in the housing. This bush is used in suspension systems where space is limited and the axial loads are not great.

3. **METALASTIK FLANGED ULTRA-DUTY BUSHES** can be supplied with buffering surfaces to limit axial movement under load. Can be used loaded axially, as anti-vibration mountings.

4. **METALASTIK DUAL AND TRIPLE ULTRA-DUTY BUSHES.** Used to give higher radial load or larger angles, sometimes both.

5. **METALASTIK BALL JOINTS,** taking large angular movements in all directions and resisting axial loads. Pre-compressed during assembly.

6. **METALASTIK B.C.** (Bonded Cone) **BUSHES** and **METALASTIK B.C.T.** (Bonded Cone Tube) **BUSHES** used in pairs pre-compressed against one another. High load capacity and stiffness in radial and axial directions. Extensively used in I.F.S. systems.
B.C. is as illustrated, B.C.T. is similar but without metal end flanges.

7. **METALASTIK CONE BUSHES** fitted in pairs with the rubber pre-compressed, giving a high stiffness and load capacity in both radial and axial directions, and angular freedom about the axis. For I.F.S. systems on heavy vehicles.

8. **SPHERILASTIK BEARINGS.** A high-duty fully-bonded bearing with a three-part shell, forced into its housing to pre-compress the rubber. Provides univeral action and a high load capacity in small space.

9. **METALASTIK ULTRA-DUTY SHACKLE PINS** developed from the ultra-duty bush, but bonded to the pin, giving a high capacity and suitable for shackles and spring eyes on 'buses and commercial vehicles.

10. **METALASTIK HEAVY-DUTY SHACKLE PINS.** This is the highest-duty form of Metalastik shackle bearing, specially designed for the heavy vehicle: it provides perfect axial control and permits high radial loadings. Backed by millions of miles of service.

METALASTIK

METALASTIK LTD., LEICESTER

The unrivalled experience and resources of the

'CASSEL' HEAT-TREATMENT SERVICE

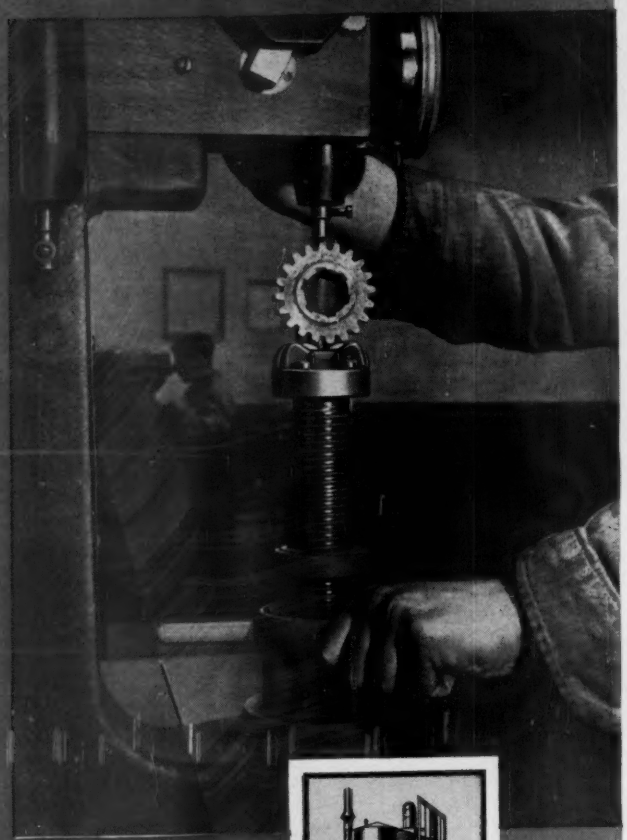
are at your disposal.

A WEALTH OF EXPERT KNOWLEDGE . . .

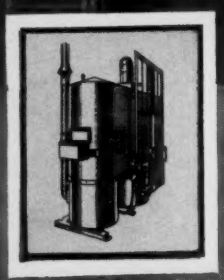
. . . lies behind every recommendation made by the 'Cassel' Heat-treatment Service. A complete range of salts and salt-bath furnaces is manufactured to meet a wide variety of heat-treatment problems.

The 'Cassel' Process offers these advantages:

- *Simple, effective control of carburising and neutral baths*
- *Uniform results easily obtained*
- *Excellent finish of treated parts*
- *No limitations on type of quench used*
- *High output for moderate capital outlay*



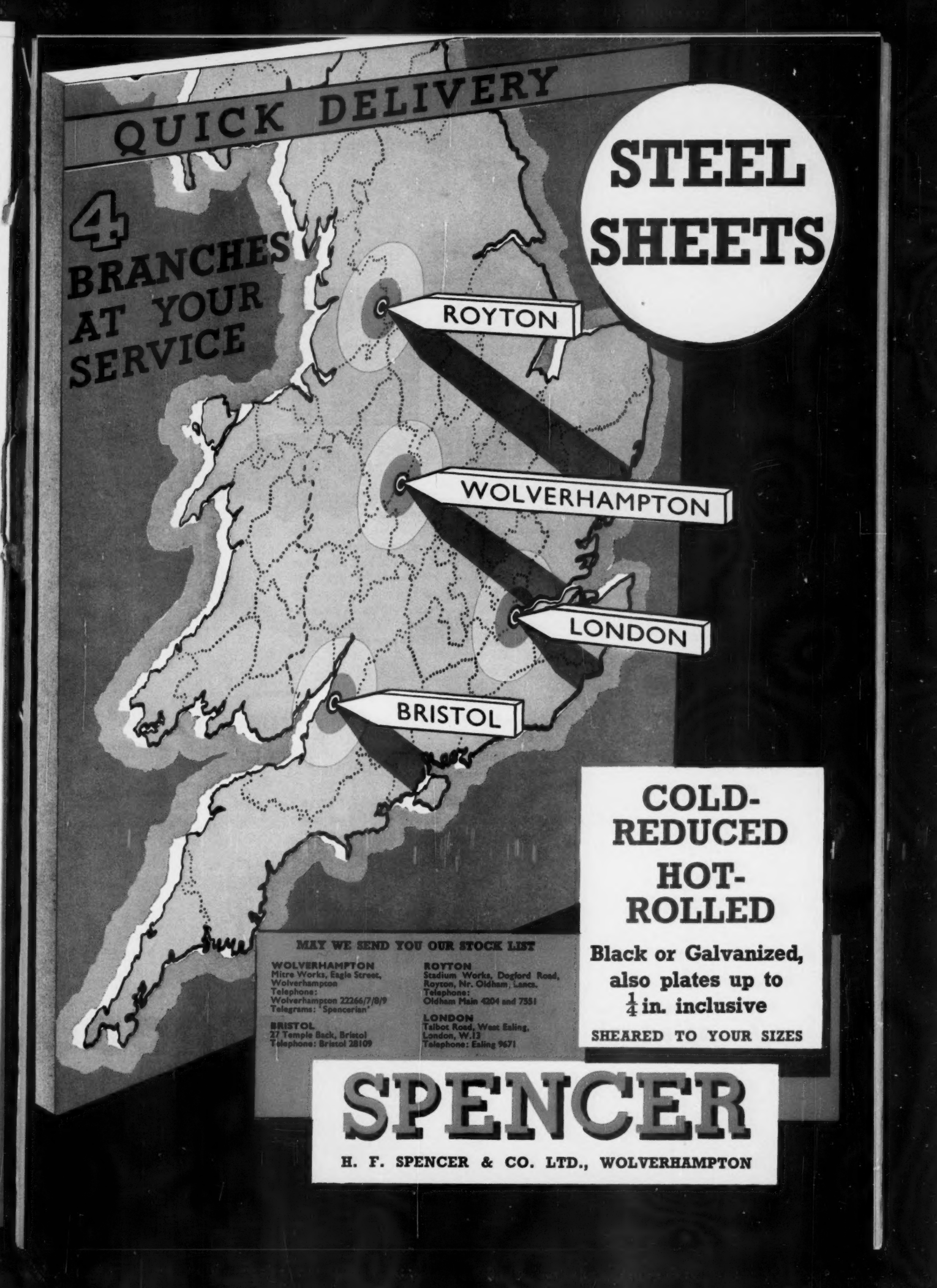
Hardness testing of heat-treated specimens.

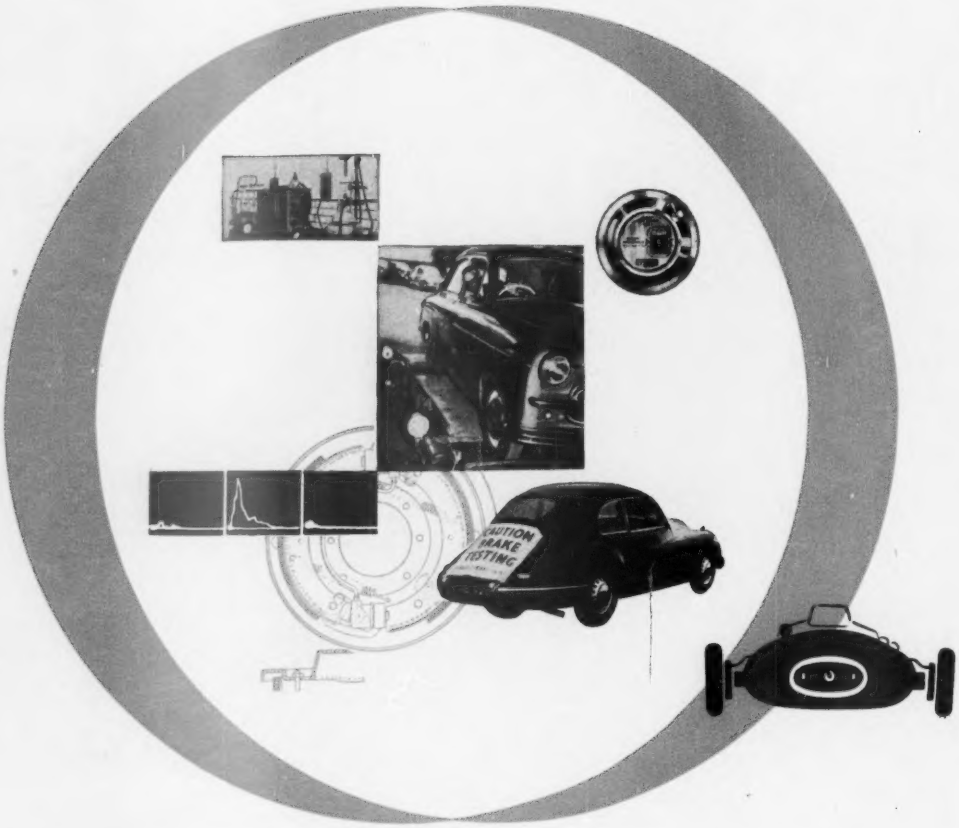


Write for further details to:

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1.

CC 180


QUICK DELIVERY
4 BRANCHES AT YOUR SERVICE
STEEL SHEETS
ROYTON
WOLVERHAMPTON
LONDON
BRISTOL
COLD-REDUCED
HOT-ROLLED
Black or Galvanized, also plates up to ¼ in. inclusive
SHEARED TO YOUR SIZES
MAY WE SEND YOU OUR STOCK LIST
WOLVERHAMPTON
Mitre Works, Eagle Street, Wolverhampton
Telephone: Wolverhampton 22266/7/8/9
Telegrams: 'Spencerian'
BRISTOL
27 Temple Back, Bristol
Telephone: Bristol 28109
ROYTON
Stadium Works, Dogford Road, Royton, Nr. Oldham, Lancs.
Telephone: Oldham Main 4204 and 7351
LONDON
Talbot Road, West Ealing, London, W.13
Telephone: Ealing 9671
SPENCER
H. F. SPENCER & CO. LTD., WOLVERHAMPTON



The position of leadership entails responsibility, and the Ferodo organisation is forever experimenting, improving and developing so that they may rightly claim FERODO WILL ALWAYS BE FIRST.

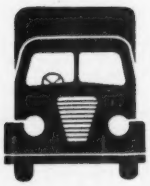
Ferodo Limited · Chapel-en-le-Frith

A Member of the Turner & Newall Organisation

FERODO

Ferodo will always be first

Ferodo Limited are the largest manufacturers of brake linings in the British Commonwealth. They have, over the years, been the first to develop and introduce such *major improvements in brake lining technique as asbestos based materials, die pressing, moulded materials, and non-wire woven materials.* The Ferodo Laboratories and Test House, unique in scope and application, are constantly engaged in testing and developing new materials and methods, keeping always a step ahead of higher speeds and mechanical developments.



Ferodo Linings are fitted as first equipment to more makes of vehicles than all other Brake Linings combined

The choice of Ferodo by this majority of Automobile Manufacturers emphasises the confidence placed in them, after the most stringent tests, by the motor industry.

brake linings · clutch facings · fanbelts

Windscreen wiper motor and other accessories — secured by Avlok Anchor Nuts

Speed assembly... slash production costs

WITH AVLOK *Blind* ANCHOR NUTS...

Avlok Anchor Nuts for securing wings

No wonder Avlok Anchor Nuts were chosen by these famous European car manufacturers for their latest models! They cut production time, reduce handling costs and completely eliminate the need for welded cage nuts, threaded inserts, screws and sheet tapping. Avlok Anchor Nuts not only bolt components together where only one side of the job is accessible—they can be easily detached and replaced whenever required. The spring-washer effect of the cage ensures that, when tightened, Avlok Anchor Nuts are perfectly shakeproof.

In the automobile industry, more and more use is being made of this revolutionary fastening system and we will be pleased to send you full details on request.

Just look at the advantages:

- *Rapidly fixed from one side*
- *Eliminates lockwashers*
- *Simply replaced from one side*
- *Absolutely shakeproof*
- *No welding or riveting*
- *Blind fixing of enormous advantage to designers*

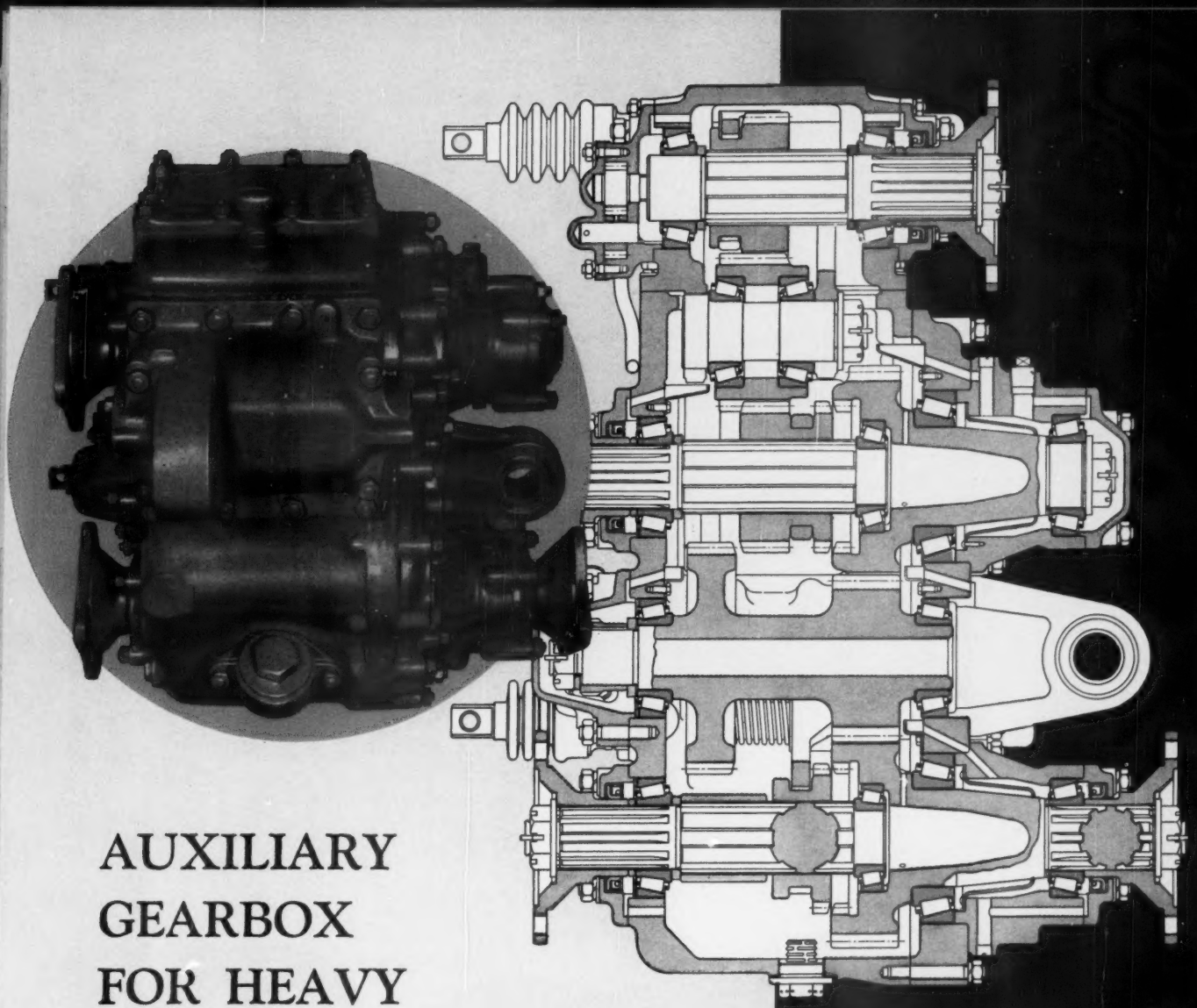
AVLOK

Regd.

ANCHOR NUTS

AVIATION DEVELOPMENTS LTD., 229-231, High Holborn, London, W.C.1.

AD10



AUXILIARY GEARBOX FOR HEAVY COMMERCIAL VEHICLES

This sturdy auxiliary gearbox for heavy commercial vehicles is made by All Wheel Drive Ltd., and has two speeds. It gives a single or twin drive to the rear, a drive to the front, and at the top a rear-facing power take-off, which can also be fitted at either side with front or rear output.

The design is of considerable interest because of the generous and sturdy construction and the careful provision of adequate arrangements for lubrication.

As will be seen from the drawing, Timken tapered-roller bearings are used throughout.

Regd. Trade Mark TIMKEN

TIMKEN

tapered-roller bearings

MADE IN ENGLAND BY BRITISH TIMKEN LTD

DUSTON, NORTHAMPTON (HEAD OFFICE); DAVENTRY & BIRMINGHAM

Telephone: Northampton 4921-8 & 3452-3 Telex No. 31-620 Telegrams: Britimken Northampton Telex

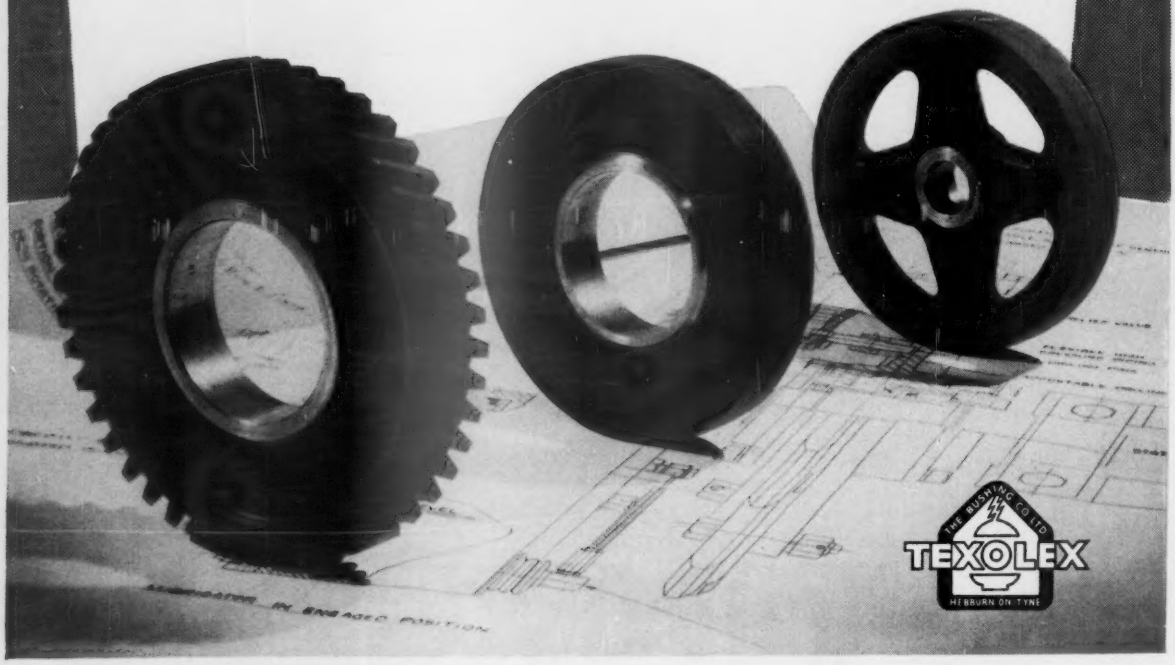
SUBSIDIARY COMPANIES: FISCHER BEARINGS COMPANY LTD., WOLVERHAMPTON
TIMKEN-FISCHER STOCKISTS LTD., BIRMINGHAM

PLASTICS FOR THE ENGINEER

One of the many industrial applications of Texolex laminated mouldings is in the motor industry where extensive use is made of this material for cam gears. Some of the largest motor manufacturing organisations have found in Texolex many of the qualities of the ideal material, offering silence in operation, lightness in weight, high mechanical strength coupled with resistance to wear and corrosion.

TEXOLEX IN THE AUTOMOBILE INDUSTRY

The Bushing Company Limited, would be pleased to give further technical information about Texolex laminated fabric gears and their suitability and operation in camshaft, jackshaft and oil pump drives.



THE BUSHING COMPANY LIMITED · HEBBURN ON TYNE · ENGLAND

TELEPHONE: HEBBURN 32241 **TELEGRAMS: "BUSHING, HEBBURN"**

As sheet

for spinnings

and pressings

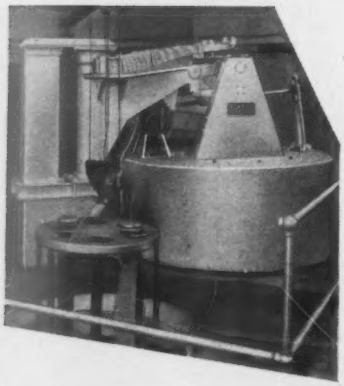
experience has sho

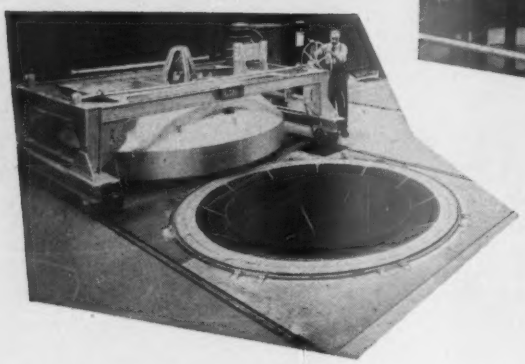
Hiduminium

makes the most of *Aluminium*

HIGH DUTY ALLOYS LIMITED SLOUGH BUCKS

All shapes... all sizes





Wild-Barfield make equipment for all heat-treatment purposes. Whether you need a standard 'C' type forced air circulation furnace or one made for a special application, you can be sure of getting maximum efficiency and that complete dependability for which Wild-Barfield furnaces are famous.

FORCED AIR CIRCULATION FURNACES

ELECTRIC WILD BARFIELD FURNACES

for all heat-treatment purposes

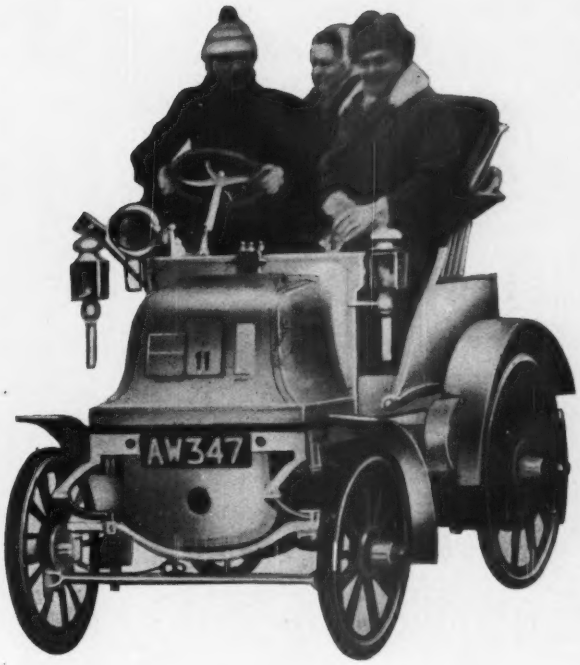
WILD-BARFIELD ELECTRIC FURNACES LIMITED

ELECFURN WORKS, OTTERSPOOL WAY, WATFORD BY-PASS, WATFORD, HERTS. Telephone : Watford 6091 (8 lines)

WB39

KIRKSTALL AXLES

WERE FITTED
TO THIS
1897
DAIMLER



THEY ARE USED TODAY
ON THE WORLD'S
BEST COACHES,
BUSES, TRUCKS,
AND DUMPERS, ETC.

KIRKSTALL FORGE ENGINEERING LIMITED
LEEDS, 5

Telephone: Horsforth 2821

Sports car body moulded by Martin Plastics Ltd., from "Duraglas" glass fabric bonded with "Bakelite" polyester resins.

The key to better plastics reinforcement

DURAGLAS
REGISTERED TRADE MARK

Standard Bedford Van fitted with one-piece "Duraglas"/plastic roof panel by R. W. Osborne & Son.

You can keep down the weight—and the cost—yet keep up the strength with "Duraglas" glass fibre reinforcements for constructional plastics. "Duraglas" can be used whenever a combination of lightness with strength and durability is desirable. Both the sports car and the van illustrated are fine examples of the use of plastics in modern bodybuilding, employing "Duraglas" glass fibre reinforcement. We shall be glad to supply further details and samples.

TURNER BROTHERS ASBESTOS CO. LTD. ROCHDALE ENGLAND
A MEMBER OF THE TURNER & NEWALL ORGANISATION

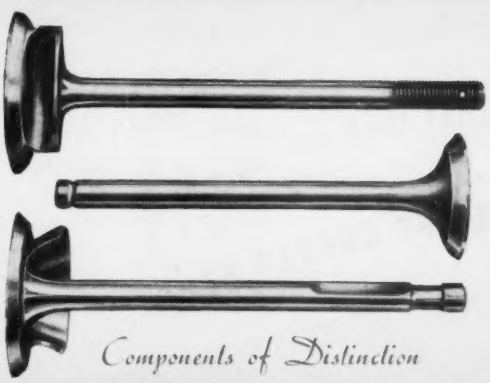
dmTA18

VALVES BY FARNBOROUGH

FARNBOROUGH ENGINEERING CO LTD · FARNBOROUGH · KENT · ENGLAND

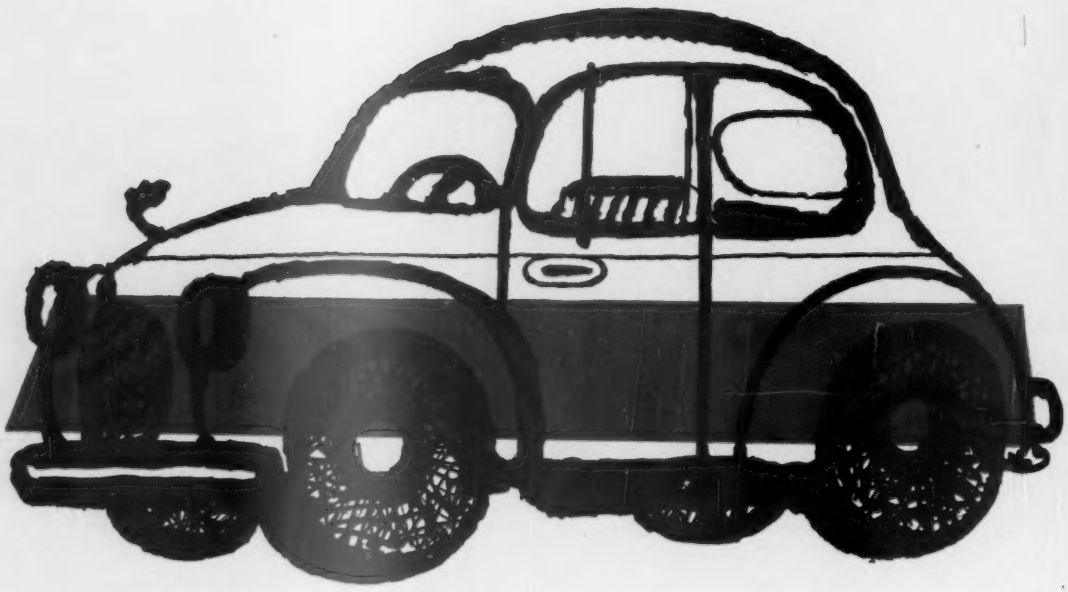
Fitted as standard by the following British, American and Continental engine builders

ADMIRALTY
A.E.C.
ALLEN
ALLIS CHALMERS
AUSTIN
BERGIUS
DAVID BROWN
CATERPILLAR TRACTOR
CHRYSLER-DODGE
CONNAUGHT
DAVEY, PAXMAN
GARDNER
HUMBER
LEYLAND
LISTER
MIRRLEES
MORRIS
McLAREN
PERKINS
RUSTON & HORNSBY
SCANIA VABIS
VICKERS-ARMSTRONG
VOLVO



Components of Distinction

from coins to cars



to mint managers and car manufacturers brass means money. so it is just as well that they can count on

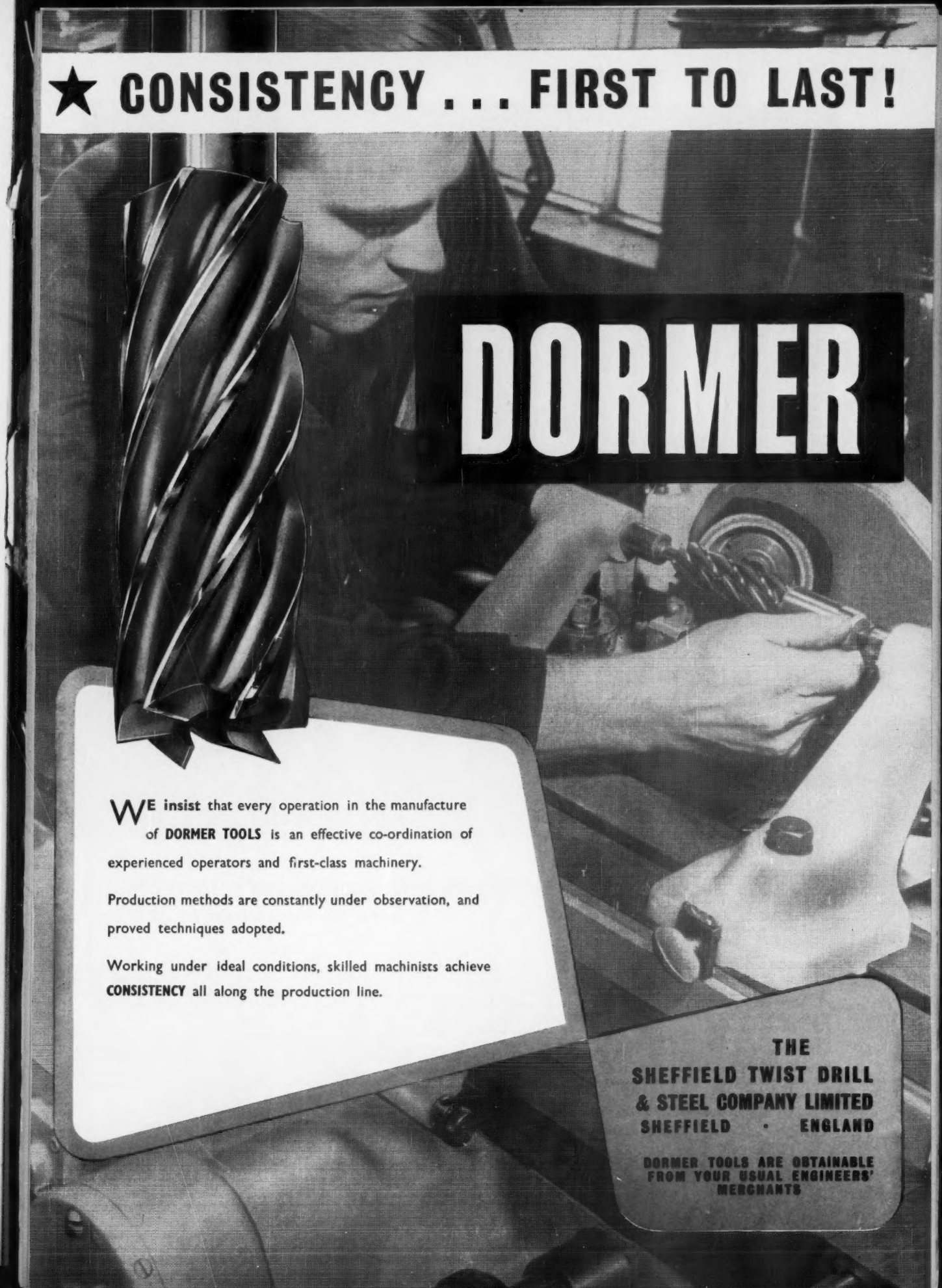
I.C.I. BRASS AND COPPER STRIP

ICI
METALS DIVISION

IMPERIAL CHEMICAL INDUSTRIES LIMITED. LONDON. S.W.1

C3

★ CONSISTENCY . . . FIRST TO LAST!



DORMER

WE insist that every operation in the manufacture of **DORMER TOOLS** is an effective co-ordination of experienced operators and first-class machinery.

Production methods are constantly under observation, and proved techniques adopted.

Working under ideal conditions, skilled machinists achieve **CONSISTENCY** all along the production line.

THE SHEFFIELD TWIST DRILL & STEEL COMPANY LIMITED
SHEFFIELD · ENGLAND

DORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

Designers with designs for tomorrow turn to Ransome & Marles

What sort of bearings do Ransome & Marles make?

We make all types of roller, parallel roller and needle roller bearings which will fully and economically meet most applications. Also, in addition to our vast standard range, we manufacture special bearings for use in conditions calling for unique designs, dimensions or materials. For instance, we undertake individual research into bearing problems for manufacturers of guided missiles. Dry lubrication, the ability to withstand corrosive fluids and enormous acceleration are examples of the special problems involved.

What about bearings for, say, high-precision equipment?

This also demands special R&M bearings. Take machine-tool grinding spindles for instance. Here ordinary limits of accuracy are wholly inadequate, and we produce bearings to ultra-precision specifications. Sometimes, also, we supply bearings made from stainless steels.

I suppose this involves pretty thorough inspection?

All our standard products are checked individually—from the first analysis of the raw material right through to the final product inspection, every R&M bearing is subject to over a hundred separate tests. So you can be sure that quality goes hand in hand with quantity when you specify R&M —and you know also that it will be the best obtainable anywhere.

RANSOME & MARLES BEARING CO. LTD., NEWARK-ON-TRENT, ENGLAND

Telephone: Newark 456 and Telex 37-306

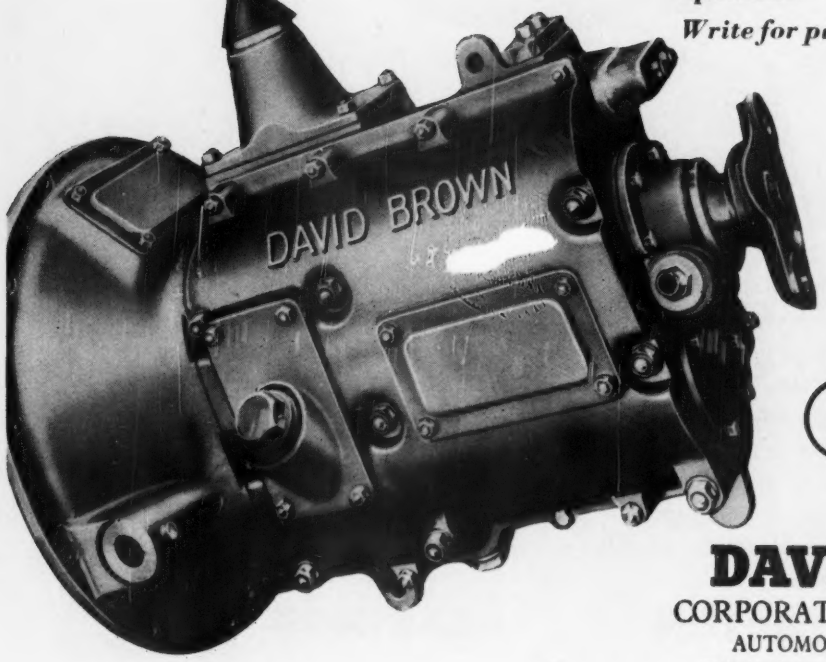
BALL & ROLLER R&M BEARINGS

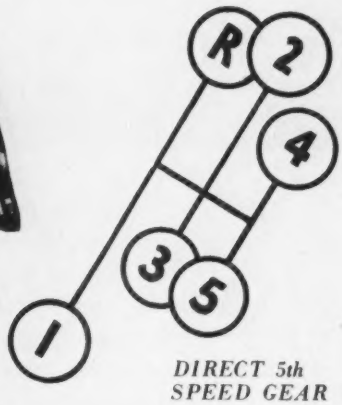
PROVED IN SERVICE

In the medium vehicle range, the David Brown Model 542 5-speed gearbox is acknowledged as the outstanding unit, and its unfailing reliability, over very high mileages, has earned it a world-wide reputation.

Offered with either centre or forward control and a choice of direct or over-drive top gear, the 542 gearbox is designed for a maximum torque of 205 lb/ft. and is characterised by its sturdiness, compactness, low weight to strength ratio, ease and quietness of operation.

Write for publications E393.26 and 27

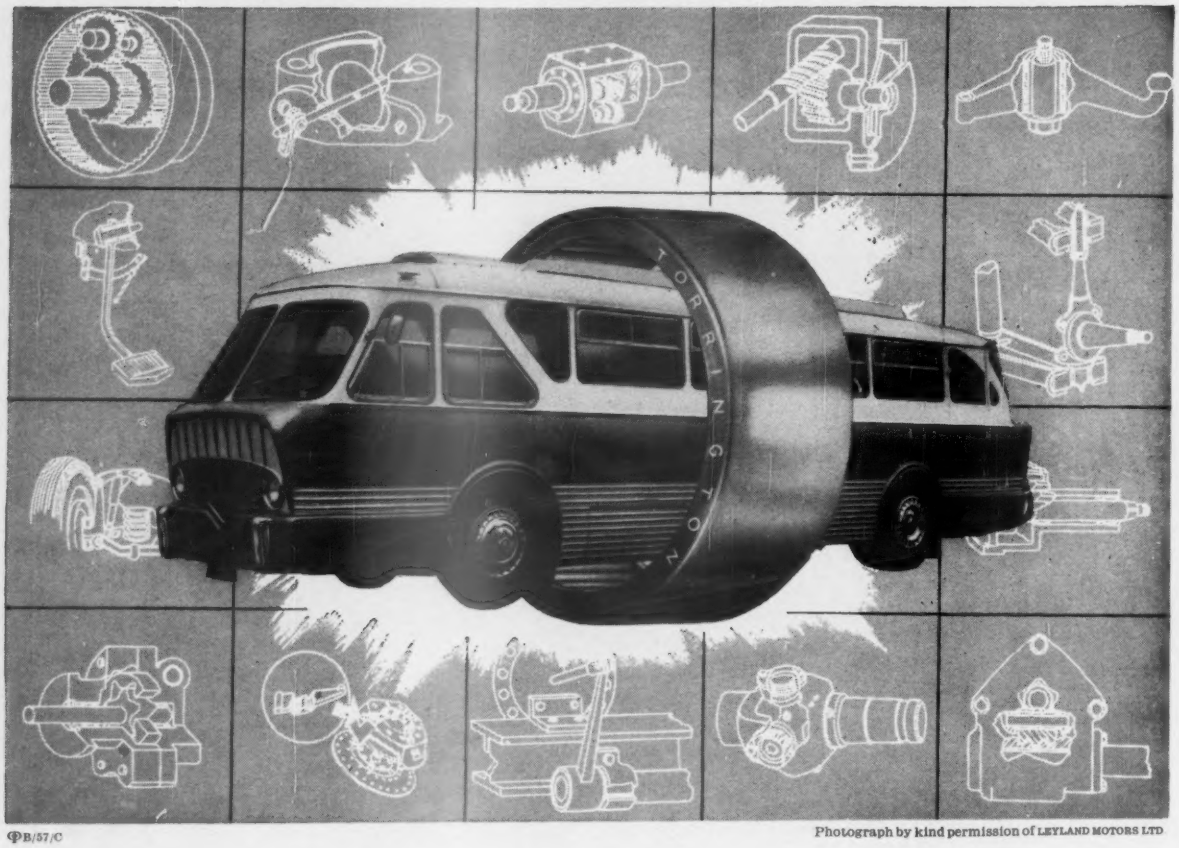




DIRECT 5th SPEED GEAR

THE
DAVID BROWN
CORPORATION (SALES) LIMITED
AUTOMOBILE GEARBOX DIVISION
PARK WORKS HUDDERSFIELD

TORRINGTON NEEDLE BEARINGS
offer the Motor Manufacturer high capacity, small size, low cost, ease of installation and long service life



ΦB/57/C

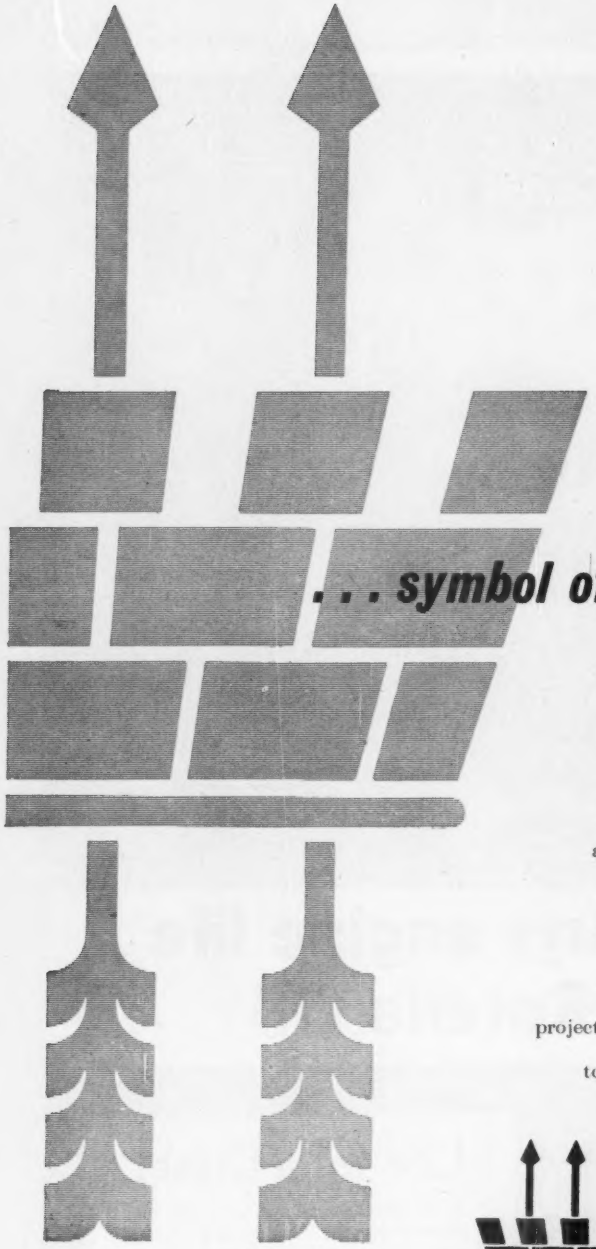
Photograph by kind permission of LEYLAND MOTORS LTD

TODAY leading manufacturers of automobiles, commercial vehicles and components have standardised on the needle bearing to such an extent that it is in use in almost every rotating and oscillating bearing application where compactness, high capacity and ease of installation are important. THE TORRINGTON NEEDLE BEARING has been "Performance Proved" in Universal Joints, Governors, Steering Gears, Suspensions, Brake Camshafts, Brake and Clutch Pedal linkage pivots, Clutch Throw-out fingers, Transmissions, Hydraulic Pumps and many other applications. Why not let our Bearings Division assist you in applying the unique characteristics of the needle bearing to your products?

TORRINGTON *NEEDLE* **BEARINGS**

Made and stocked at our Coventry factory

THE TORRINGTON COMPANY LIMITED, Bearings Division
Head Office & Works: Torrington Avenue, Coventry. London Office: 7-10 Eldon Street, E.C.2. Glasgow Office: 14 Moir Street, C.1



. . . symbol of quality and service

From concept to finished product, the precise standards demanded to-day depend on the efficient co-ordination of all available knowledge, experience and manufacturing facilities. The BIRFIELD Group of Companies, serving particularly the Automotive, Railways, Aviation and General Engineering fields, applies its collective knowledge and resources to all projects undertaken within the Group. BIRFIELD service to industry is comprehensive, expert and dependable.

THE
BIRFIELD
GROUP

BIRLITE BATTERIES LTD · BOUND BROOK BEARINGS LTD · CASTINGITE LTD
COX ATMOS PRODUCTS LTD · FORGINGS AND PRESSWORK LTD · HARDY SPICER LTD
T. B. FORD LTD · INTERMIT LTD · KENT ALLOYS LTD
G. K. LANCASTER (LONDON) LTD · LAYCOCK ENGINEERING LTD · R. JONES & CO. LTD
ODDY ENGINEERING LTD · THE PHOSPHOR BRONZE CO. LTD
SALISBURY TRANSMISSION LTD · TOOLMAKERS & DESIGNS (COVENTRY) LTD
THE VACUUM BRAKE CO. LTD · UNIPOWER RZEPPA LTD

BIRFIELD INDUSTRIES LIMITED · STRATFORD HOUSE · LONDON · W·1

Mr. Nichols buys engine life with Shell Rotella Oil

Life for a Diesel

A. W. Nichols and Son Ltd., agricultural merchants of Stamford, have always found it pays to use Shell Rotella in their fleet of diesel lorries. They ran one Perkins P6 engine for 103,000 miles without the head being taken off, and no trouble was experienced. "It ran to 130,000 miles," says Mr. Nichols, "was then rebored and up to now has done more than 195,000 miles completely trouble free on Shell Rotella Oil."

SHELL Leadership in Lubrication

THE UNIVERSAL UNIT

Illustrated above is the Type 3 'Universal' steering gear which incorporates the hydraulic control valves mounted upon our type '861' manual gear. This is for use with a separate power pump and with power cylinders operating on the steering linkage. Further particulars will be sent on request.

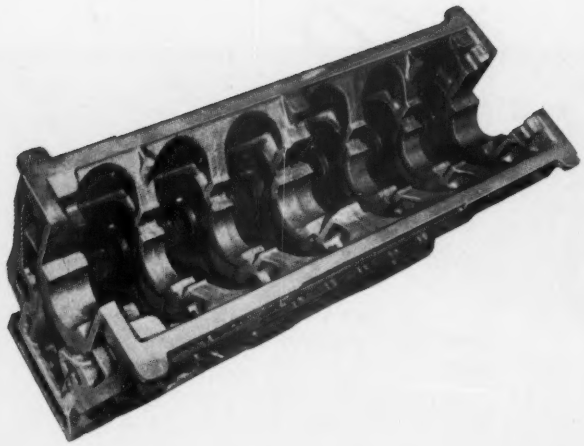
ADAMANT ENGINEERING CO. LTD., DALLOW ROAD, LUTON

Sole proprietors of the Marles Steering Company Ltd.

Telephone: Luton 2662 (4 lines) Telegrams: Adamant, Phone, Luton

MARLES

CLAYTON DEWANDRE CO. LTD.
A.P.33



castings
by
STERMET

SAND CASTING IN GREY IRON OF SIX BORE OIL ENGINE BLOCK
By courtesy of Rolls-Royce Ltd.

1907 50 1957

This year brings the golden jubilee of Sterling Metals. For half a century the Company's hallmark has been an unexcelled reputation for skill, quality and craftsmanship. One of the world's largest producers of Elektron magnesium castings, and extensively equipped with iron and aluminium foundries, Sterling Metals will maintain their tradition of service to the aircraft and automobile industries during the years to come.

Castings are made in a comprehensive range of aluminium alloys and the 'Elektron' Magnesium-Zirconium-Thorium series by sand, permanent mould and precision mould methods. Sterling Metals are also specialists in cast iron cylinders and heads.

STERMET
REGISTERED TRADE MARK

STERLING METALS LTD COVENTRY & NUNEATON

Quality Products

A new type Fire-resistant Hydraulic Fluid.

HOUGHTO-SAFE 271

combines the safety of a fire-resistant fluid with outstanding efficiency.

In plants performing Die-casting, Welding, Hot Press Forging and other hydraulic operations near flames or great heat, Houghto-Safe 271 is the solution of a big problem.

Houghto-Safe 271 is reinforced to ensure many other benefits:

- High film strength provides greater protection for metal parts for longer periods.
- Extra service life of equipment.
- No ill-effects on type of packings normally used.
- Houghto-Safe 271 maintains an unusually even viscosity through widely fluctuating temperatures, meaning high performance value—less wear and tear.
- The fluid is pumpable at temperatures down to as low as minus 15 deg. F.

HOUGHTO-SAFE IS SAFE — and much more besides.

Research Service

Edgar Vaughan & Co. Ltd.

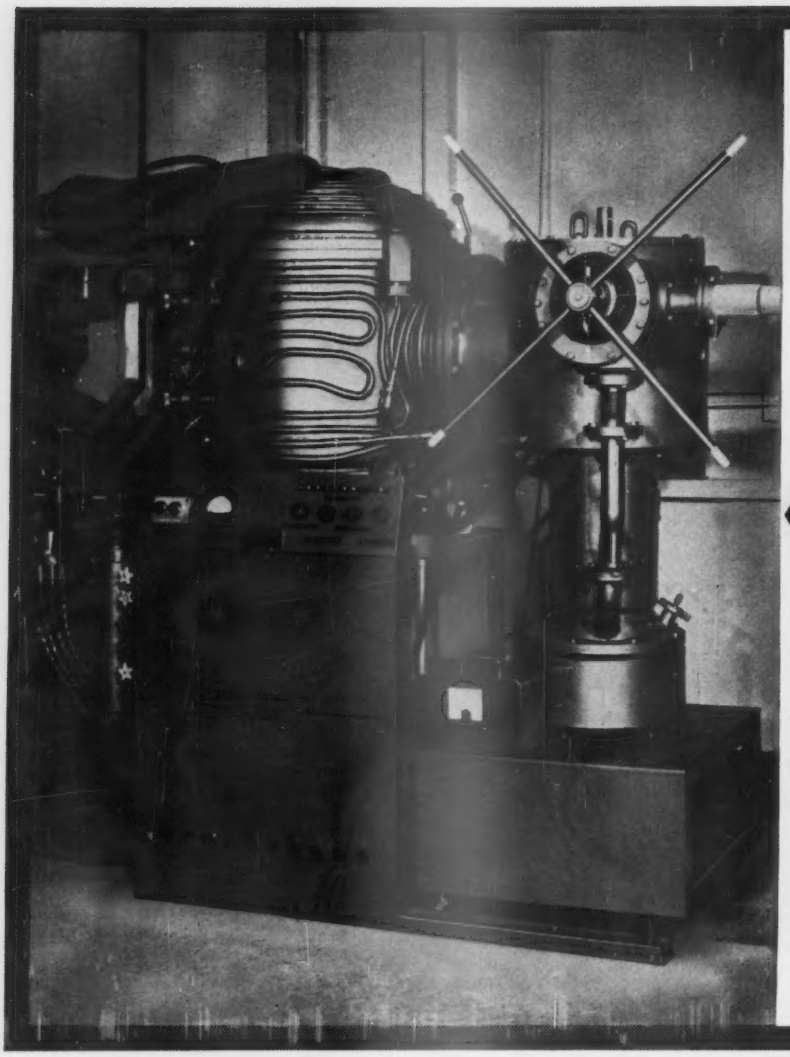
BIRMINGHAM 4 · ENGLAND

Works and depots at:

BIRMINGHAM · MANCHESTER
LIVERPOOL · SOUTHALL (Middx.)
GLASGOW · BRISTOL

Supreme
in their class
The aluminium casting illustrated is part of the vital pressurisation system and is one of many components cast by PBM for the Britannia under close laboratory observation.
Precision Machining for the aircraft industry is an important service also available to constructors.
PBM
PERRY BARR METAL COMPANY LTD., GREAT BARR, BIRMINGHAM 22A
TELEPHONE: GREAT BARR 1794-5-6

G.E.C. High Temperature Vacuum Furnaces



For temperatures up to 1800-2000°C

Operating vacuum better than 10^{-4} mm. Hg.

For efficient process heating use

G.E.C.

APPLICATIONS INCLUDE:
Sintering, Degassing
Brazing with nickel chromium alloys
Heat treating titanium, tantalum, zirconium

Write for further details.

FURNACES • HIGH FREQUENCY • INFRA-RED

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON W.C.2

vehicle springs

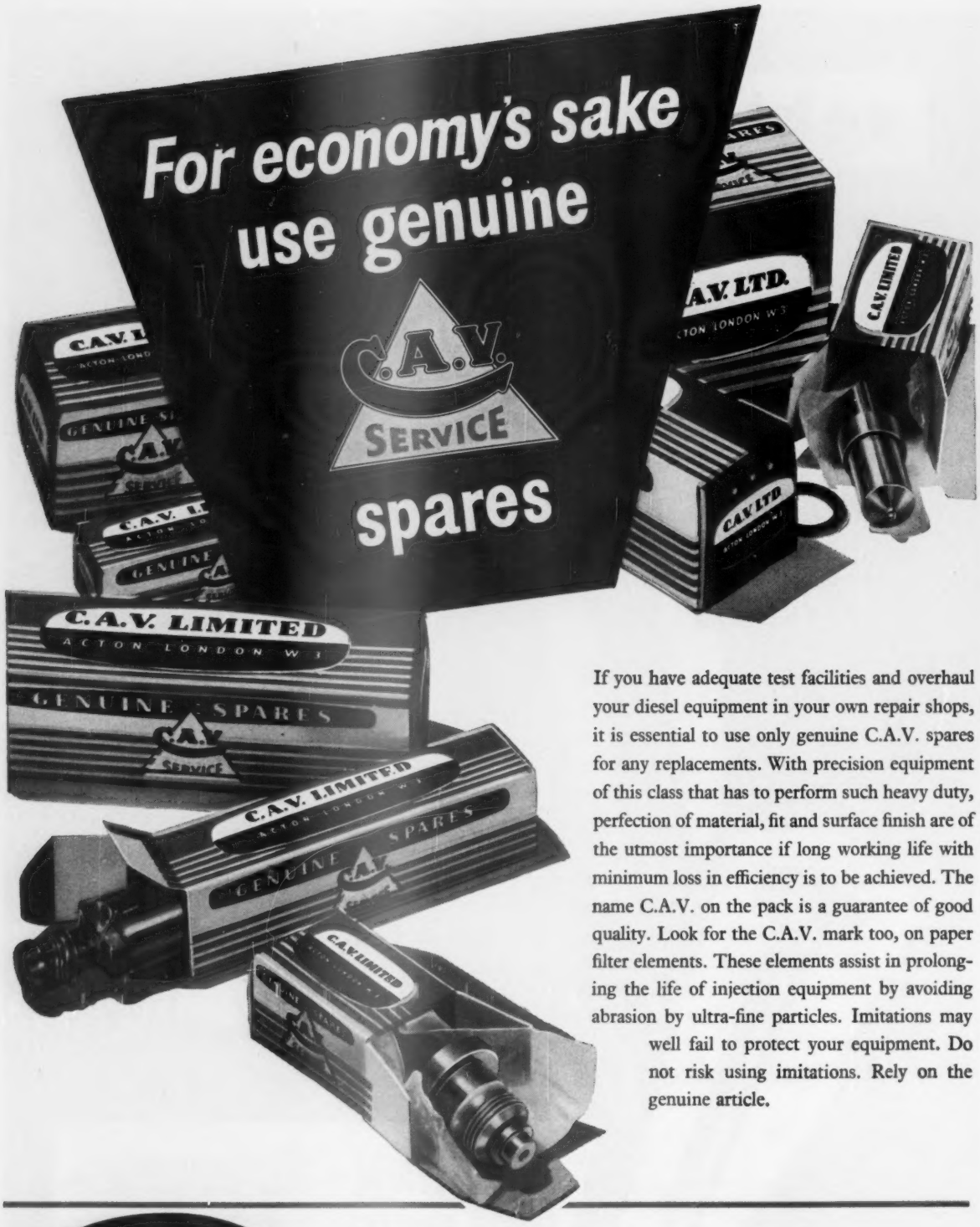
to your specification

KANTLINK SPRING WASHERS

Will not link together into chains; in all sizes A.S.A. or S.A.E. medium type.

TOLEDO WOODHEAD SPRINGS LIMITED · SHEFFIELD 3

TWS64



If you have adequate test facilities and overhaul your diesel equipment in your own repair shops, it is essential to use only genuine C.A.V. spares for any replacements. With precision equipment of this class that has to perform such heavy duty, perfection of material, fit and surface finish are of the utmost importance if long working life with minimum loss in efficiency is to be achieved. The name C.A.V. on the pack is a guarantee of good quality. Look for the C.A.V. mark too, on paper filter elements. These elements assist in prolonging the life of injection equipment by avoiding abrasion by ultra-fine particles. Imitations may well fail to protect your equipment. Do not risk using imitations. Rely on the genuine article.

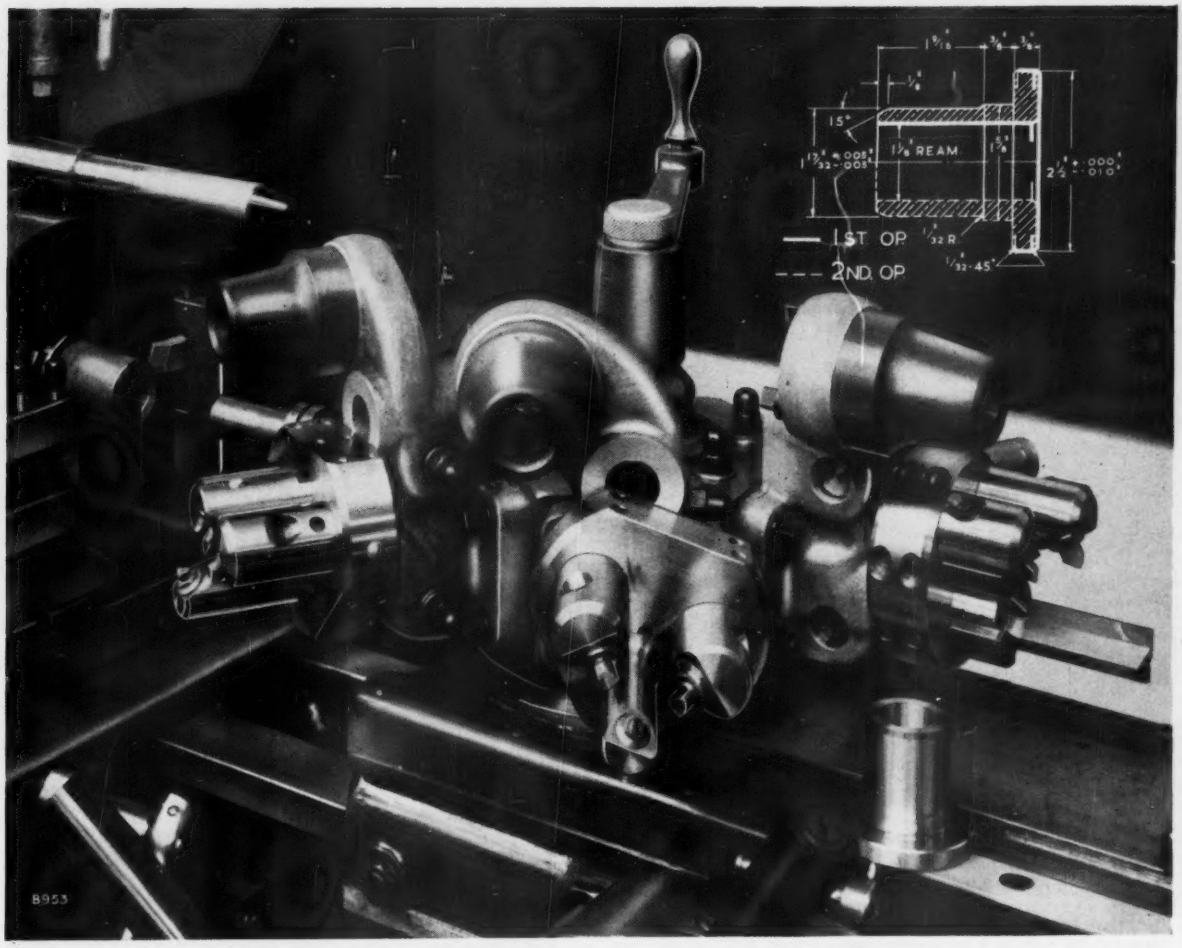
C.A.V.

The World's Leading Manufacturers of

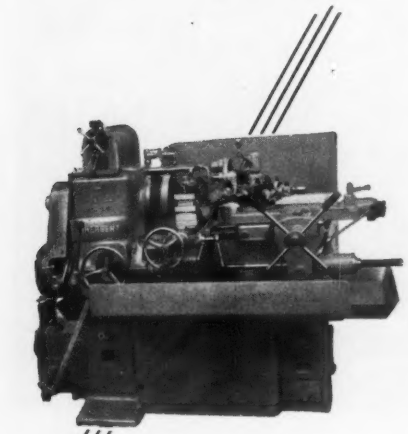
FUEL INJECTION EQUIPMENT

C.A.V. LIMITED, ACTON, LONDON, W.3

AF 859



HERBERT No. 2D Capstan Lathe. The ideal machine for bar work up to 1½″ diameter and chuck work up to 9″ swing.



Tooling on a Herbert No. 2D Capstan Lathe for completely machining a phosphor-bronze pilot bush during one complete cycle of the turret. Hand loading and removal are eliminated. After the first operation the casting is removed on a work carrier from the dual-purpose chuck jaws, then transferred and reversed, by hand, from one work carrier to another (both mounted on the turret) for loading for the second operation. All machining except front and flange faces is done by pre-set Microbore cluster tooling. Ardoloy-tipped tools used thoughout. Total time, 2 minutes.

available for Early Delivery.

Other small Herbert Lathes available for prompt delivery include :— No. 0 Electro-pneumatic Capstan Lathe, No. 3 Capstan Lathe and No. 2 Flashcap Lathe.

ALFRED HERBERT LTD · COVENTRY · ENGLAND

AD.299

DURALUMIN

REGD. TRADE MARK

takes a load off overheads

In this drop-sided truck, 'Duralumin' saves wear, tare, tyres, fuel and tax. Mounted on a standard B.M.C. chassis, its capacity has been increased by a third, and yet the weight has been kept down sufficiently to qualify for the same rate of tax. After extending the chassis by 3 ft. 9 in. with a Baico extension, the truck was fitted with a 21-ft. 'Duralumin' body instead of the 16-ft. standard body normally supplied by the manufacturers.

This use of 'Duralumin' may suggest applications in your own vehicle construction. Strong as steel yet only a third its weight, corrosion-resistant, hardwearing and easy to clean, this rustless light alloy offers important advantages to all vehicle operators.

(Above) The 7-ton B.M.C. forward control Diesel chassis fitted with a 21-ft. body. Premier Motor Company (Birmingham) supplied the chassis. Bodywork was built by the Duramin Engineering Company—an entirely independent organisation.

(Right) Mechanic's eye-view of the chassis showing the Duramin Engineering Company's tongued and grooved 'Duraplank' flooring made from 'Duralumin'.

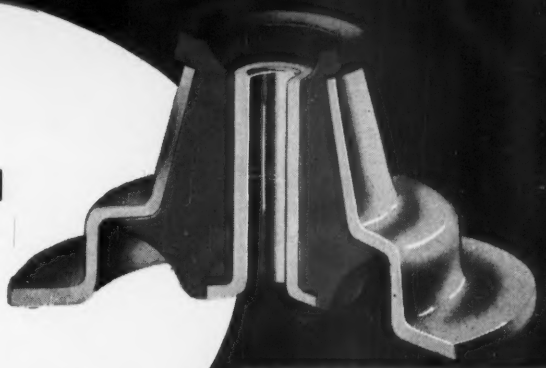
JAMES BOOTH & COMPANY LIMITED · ARGYLE STREET WORKS · BIRMINGHAM 7

Extrusions, large forgings, plate, sheet, strip, tubes and wire in brass and copper, as well as light alloys

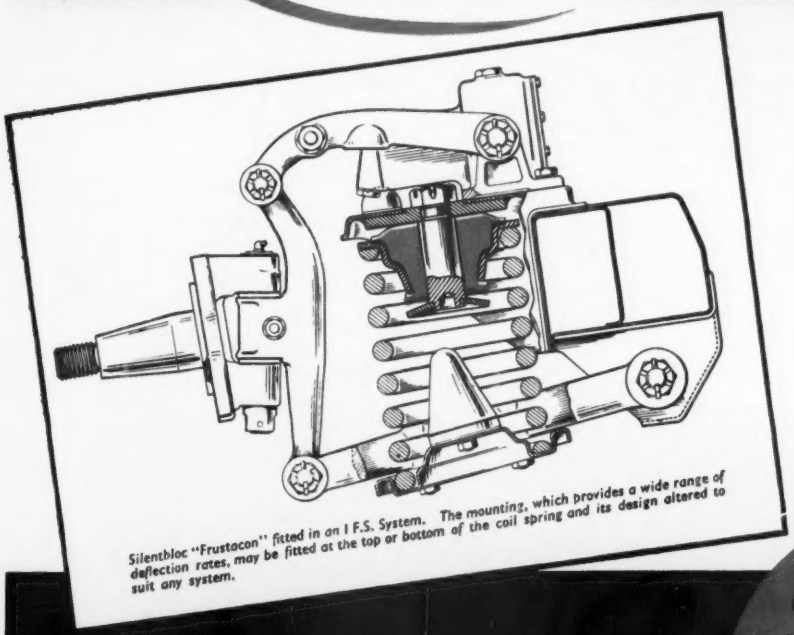
TGA 18797

Silentbloc FRUSTACON..

... the first scientifically designed flexible mounting fitted to the I.F.S. of a Production Car



The 'Frustacon' mounting fitted to the I.F.S. of the Rover '75'. Sectioned to show rubber.



Silentbloc "Frustacon" fitted in an I.F.S. System. The mounting, which provides a wide range of deflection rates, may be fitted at the top or bottom of the coil spring and its design altered to suit any system.

To minimise the transmission of road noise to the body by the coil springs, Silentbloc Frustacon mountings have been incorporated in the I.F.S. of the Rover '75'. This notable step forward in the reduction of noise is another example of co-operation between car manufacturers and Silentbloc Ltd.

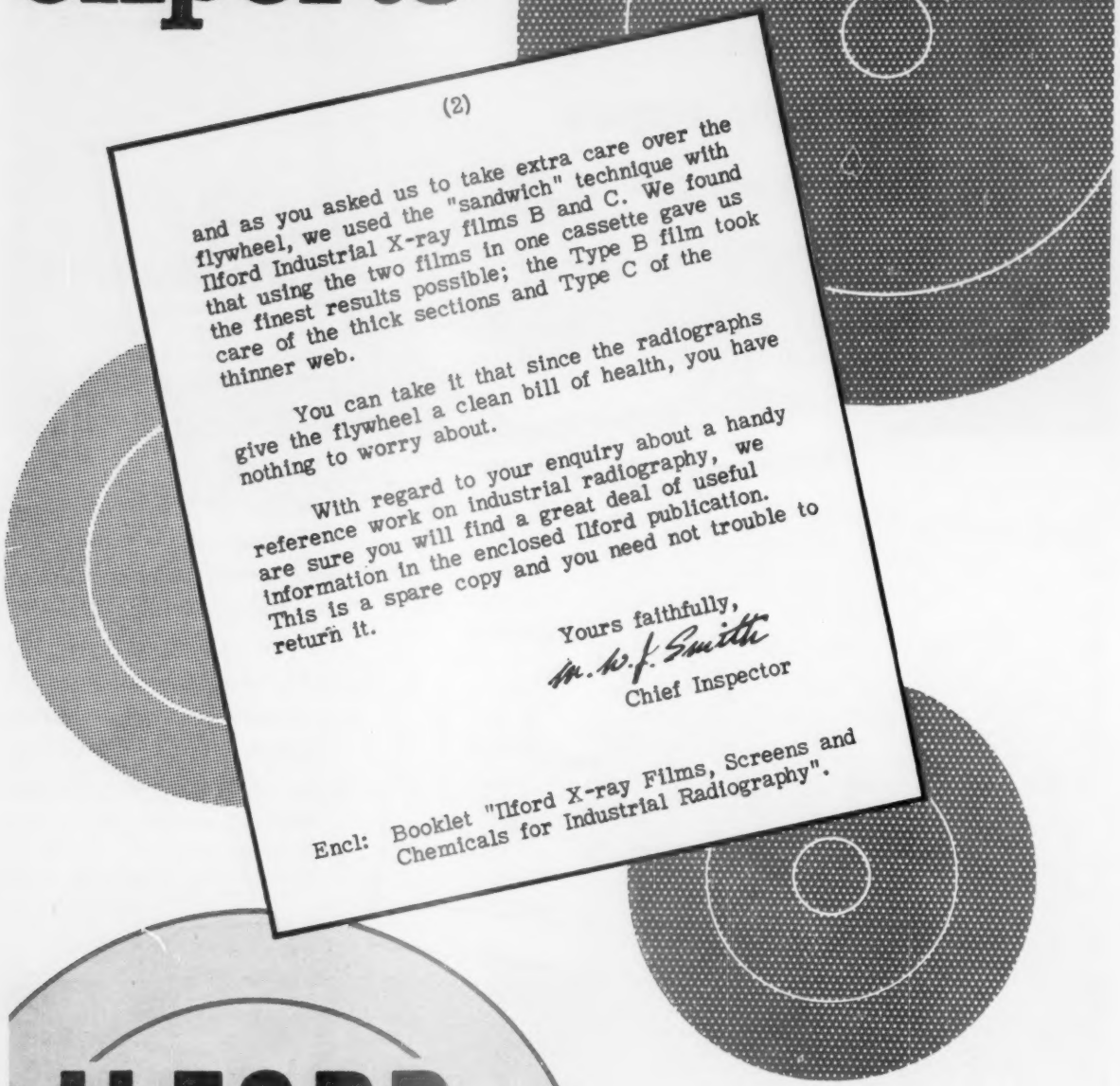
DESIGNERS AND MANUFACTURERS OF RESILIENT UNITS FOR MORE THAN 25 YEARS

SILENTBLOC LTD.

MANOR ROYAL, CRAWLEY, SUSSEX

Tel. Crawley 2100

Between experts



(2)

and as you asked us to take extra care over the flywheel, we used the "sandwich" technique with Ilford Industrial X-ray films B and C. We found that using the two films in one cassette gave us the finest results possible; the Type B film took care of the thick sections and Type C of the thinner web.

You can take it that since the radiographs give the flywheel a clean bill of health, you have nothing to worry about.

With regard to your enquiry about a handy reference work on industrial radiography, we are sure you will find a great deal of useful information in the enclosed Ilford publication. This is a spare copy and you need not trouble to return it.

Yours faithfully,
W. H. F. Smith
Chief Inspector

Encl: Booklet "Ilford X-ray Films, Screens and Chemicals for Industrial Radiography".

ILFORD

X-RAY FILMS

FOR INDUSTRIAL RADIOGRAPHY

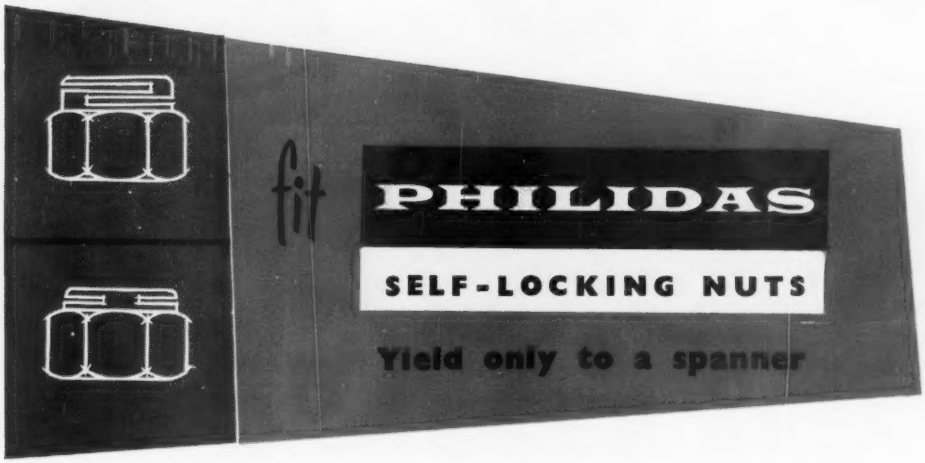
ILFORD LIMITED · ILFORD · LONDON

Photograph of Viscount aircraft by courtesy of British European Airways.

Self-locking nuts in all standard threads, sizes, platings and finishes for the Aircraft, Automobile, Electrical and Engineering Industries. Wheel, Anchor, Strip Nuts, etc. in steel, brass, bronze, stainless steel or light alloy.

PHILIDAS make nuts that are tough through and through; all-metal one-piece nuts that stay put—totally unaffected by heat changes, vibration, oil and constant use. Other vital advantages: with their opposing torque cross-cuts feature Philidas self-locking nuts yield *only* to a spanner, and can be safely used over and over again. Progress wouldn't be secure without them.

For safety, efficiency and economy, Philidas self-locking nuts are used by Vickers-Armstrongs Ltd., The Bristol Aeroplane Co. Ltd., Ford Motor Co., The Rover Co. Ltd., The General Electric Co. Ltd. and Auster Aircraft Ltd.



PHILIDAS DIVISION OF WHITEHOUSE INDUSTRIES LIMITED

Ferrybridge, Knottingley, Yorks. Telephone: Knottingley 2323 (5 lines) Telex: 55-242. Telegrams: Balbearing Ferrybridge

LONDON OFFICE: 44 Hertford Street, W 1 Telephone: Legation 3888 Telex: 2-3549 Telegrams: Balbearing London

You won't often see a *SOUNDER* OF SWINE, or a *SINGULAR* OF BOARS, or a *CETE* OF BADGERS but you'll always find an ABUNDANCE OF BEARINGS

at **WALKERS**

Complete London stocks include :
Ball and Roller Bearings by Hoffman, Fischer, SKF, R & M and Timken; Thrust Bearings; Steel, Phosphor Bronze and Stainless Balls; Grease Nipples; Lubricators; Ball and Plain Bearing Plummer Blocks; Roller Bearing Plummer Blocks; Shafting and Shafting Collars, and complete Transmission Equipment.

If any of your requirements are in the nature of NON STANDARD or SPECIAL ITEMS to your own particular details contact us if you require assistance. Our wide knowledge and experience as SPECIALISTS is at your service.

M. W. WALKER & STAFF LTD
ENGINEERS MERCHANTS
IBEX HOUSE, MINORIES, LONDON, E.C.3
Phone: ROYal 8191 (10 lines) 'Grams: Makerlaw, Fen, London
MIDDLE EAST BRANCH—BAHRAIN PERSIAN GULF

NEW ANDRE AIR SPRINGS FOR COMMERCIAL AND PASSENGER VEHICLES

The Andre Air Spring consists of two simply installed Air Pillows, one each side of the vehicle, whether single or tandem axle arrangement, but they can also be fitted in wishbone suspension arrangements or independent trailing arm suspensions. The pressure is maintained in the Pillows from the vehicle air brake system, or from a separate compressor when air brakes are not fitted. The suspension assembly can be arranged with rubber bushing so as to eliminate all lubricating points.

AUTOMATIC LEVELLING

A suspension incorporating Andre Air Springs and levelling valves assures that the floor of the vehicle is always parallel to the axle, thus uneven loading and severe crown road conditions etc. are overcome, giving a more pleasant and easy ride for the driver. For Passenger Vehicles step heights remain constant irrespective of load.

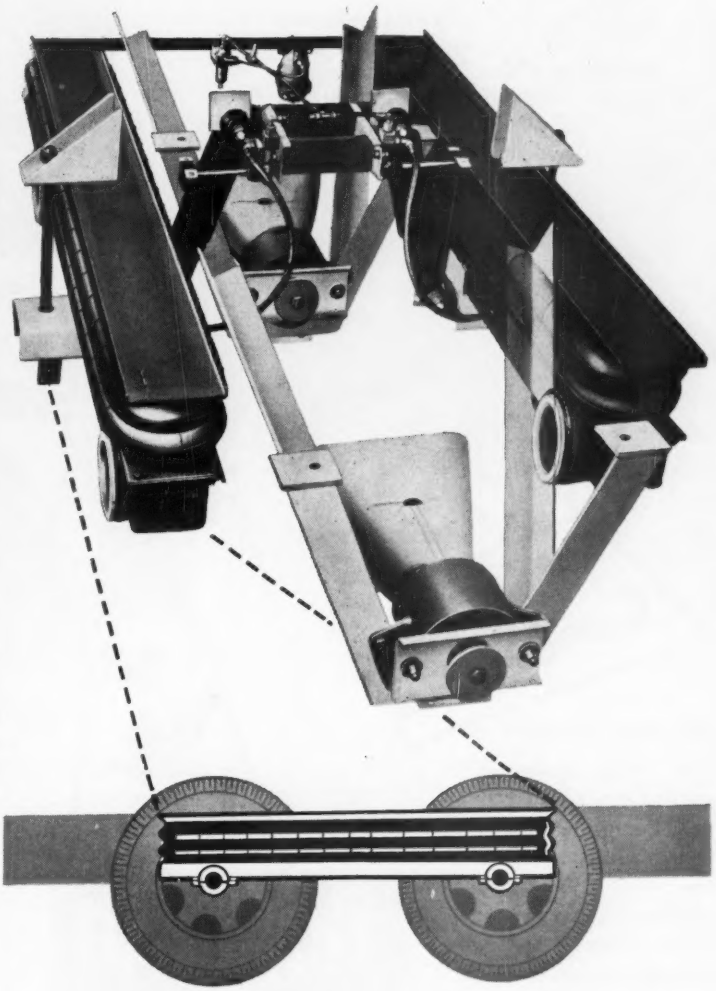
ALWAYS THE SAME RIDE WHETHER LIGHT OR LADEN VEHICLE

A feature of air springing is that, due to the action of the levelling valves, the position on the load deflection graph remains constant irrespective of load; consequently the frequency remains the same for all conditions of service. This also has the effect of eliminating bouncing due to resonance conditions, thus reducing maintenance not only of the suspension but chassis and body. It also affords greater protection for the goods or passengers being carried.

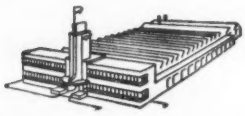
INCREASED SAFETY

This ideal suspension gives greater tyre life.

We invite you to approach us with your problems, when we shall be pleased to co-operate with you on all technical matters appertaining to this great new advance in suspension systems.



Three-and-a-half acres of specialised Rubber Technology.



TAS/AR.122

ANDRE RUBBER

ANDRE RUBBER COMPANY LIMITED

KINGSTON BY-PASS, SURBITON, SURREY

Telephone: Elmbridge 6580/3. *Telegrams: Andre, Surbiton.*

(A SILENTBLOC COMPANY)

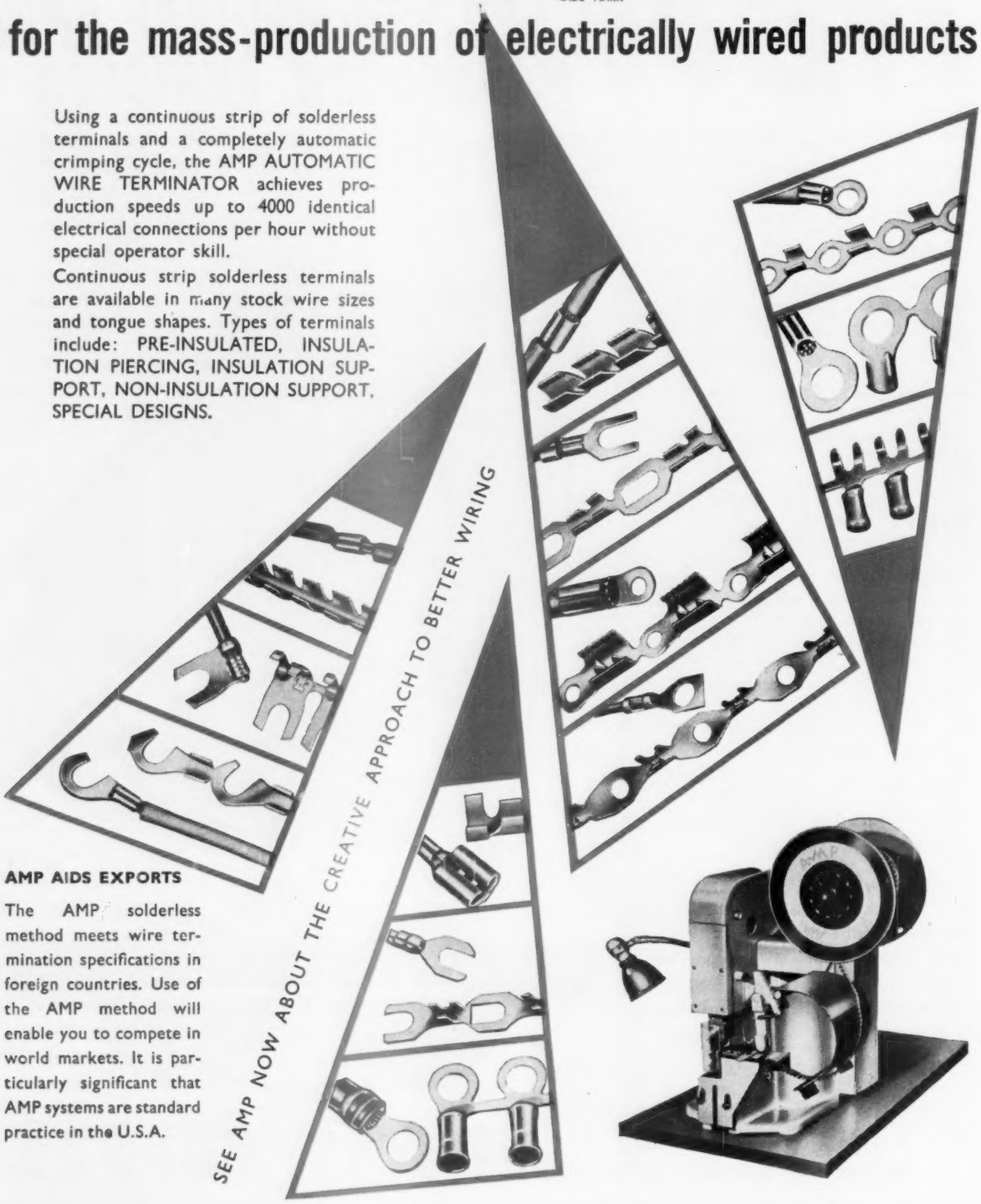
AMP *Auto-strip*

TRADE MARK

for the mass-production of electrically wired products

Using a continuous strip of solderless terminals and a completely automatic crimping cycle, the AMP AUTOMATIC WIRE TERMINATOR achieves production speeds up to 4000 identical electrical connections per hour without special operator skill.

Continuous strip solderless terminals are available in many stock wire sizes and tongue shapes. Types of terminals include: PRE-INSULATED, INSULATION PIERCING, INSULATION SUPPORT, NON-INSULATION SUPPORT, SPECIAL DESIGNS.



AMP AIDS EXPORTS

The AMP solderless method meets wire termination specifications in foreign countries. Use of the AMP method will enable you to compete in world markets. It is particularly significant that AMP systems are standard practice in the U.S.A.

AMP

TRADE MARK

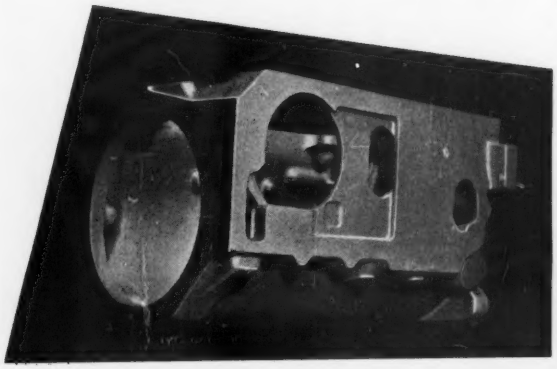
AIRCRAFT-MARINE PRODUCTS (GT. BRITAIN) LTD.

London Sales Office: DEPT. 12, 60 KINGLY STREET, LONDON W.1 Telephone: REG 2517-8 and 3681-2-3

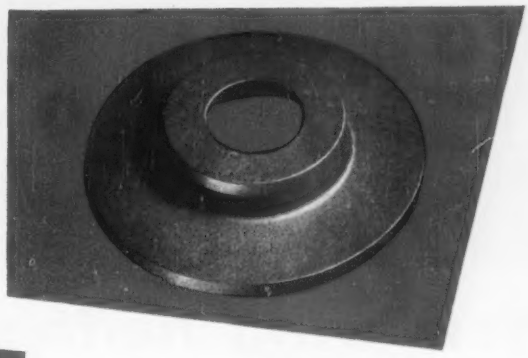
Works: SCOTTISH INDUSTRIAL ESTATES, PORT GLASGOW, SCOTLAND. AP323/46

Darcast keeps pace with Progress

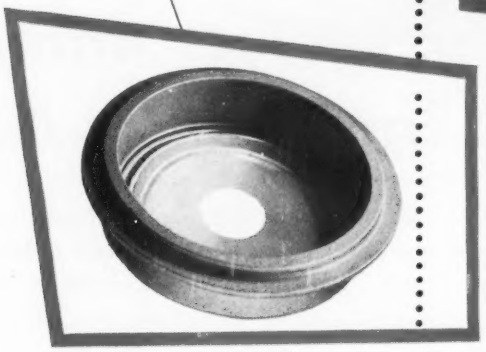
The Control and Technique
developed for the production of
High Duty Iron Castings
by the Darcast Foundries
is ready to meet developments
of the Motor Industry.



AUTOMATIC GEARBOX CASE *(COURTESY OF ROLLS-ROYCE LTD)*



BRAKE DISC *(COURTESY OF DUNLOP RIM & WHEEL CO LTD)*



COMPOSITE STEEL & CAST IRON BRAKE DRUM
(COURTESY OF VAUXHALL MOTORS LTD)

DARCAST

DARTMOUTH AUTO CASTINGS LIMITED
SPECIALISTS IN HIGH DUTY IRON CASTINGS FOR THE MOTOR INDUSTRY

SMETHWICK 40
BIRMINGHAM

New wing neither inflicts damage— nor incurs it!

A man must be either very competent—
or very irresponsible to laugh at a mishap like this.
Our man is the competent one. He knows he has neither done, nor suffered any harm, his EMPIRE RUBBER WINGS ensure that. Many hours of moving a heavy lorry within confined space have taught him their value: he never appreciated anything more.

RB.96

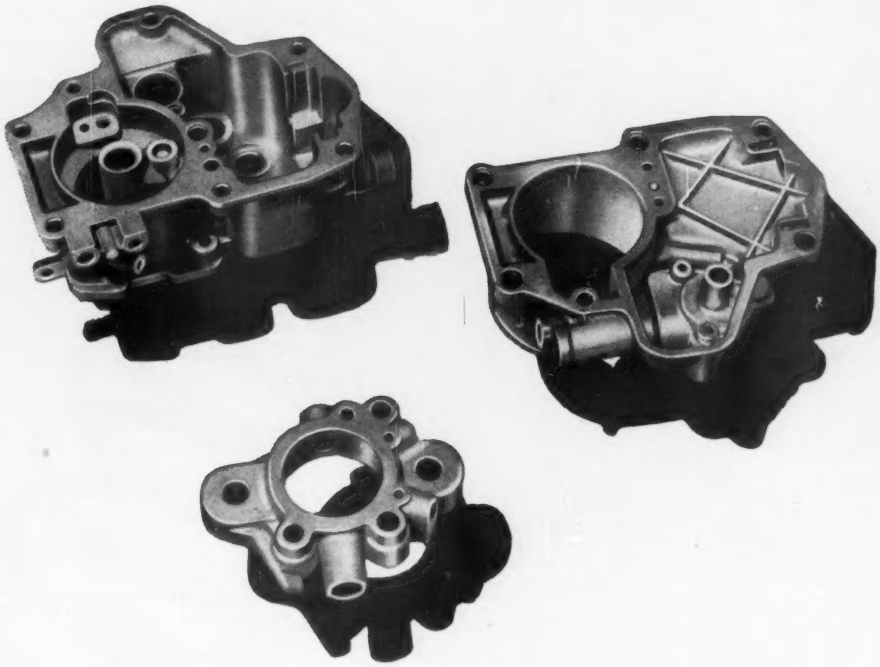
Give your driver the peace of mind that comes from knowing that his wings can neither inflict damage— nor can incur it. Save yourself the inconvenience, the loss of time and money — that results from vehicles put off the road through wing damage. The new EMPIRE RUBBER WING awaits your convenience and your driver's pleasure.

EMPIRE RUBBER WINGS.

EMPIRE RUBBER COMPANY—RUBBER BONDERS LTD., DUNSTABLE, ENGLAND

TODAY'S PROBLEMS IN INDUSTRY

Cutting Machining Time



In these days of competition both at home and abroad, machining time is a vital factor in maintaining competitive prices. It is expensive in labour and materials, and accounts for a considerable proportion of overall production costs. One way of cutting it to a minimum, however, is zinc die casting. Consider carburettors, for example. These are one of the first component parts for which zinc alloy die castings were regularly used, and as their design has become more and more complicated, die castings have proved themselves to increasing advantage. No other process allows such fast production of accurately held, complex shapes. Cored holes need only reaming or, where necessary, tapping; and the free machining qualities of zinc alloys make such operations easy and fast. Mating surfaces can often be used as cast. Justifiably this process is claimed to be the shortest distance between raw material and finished product.

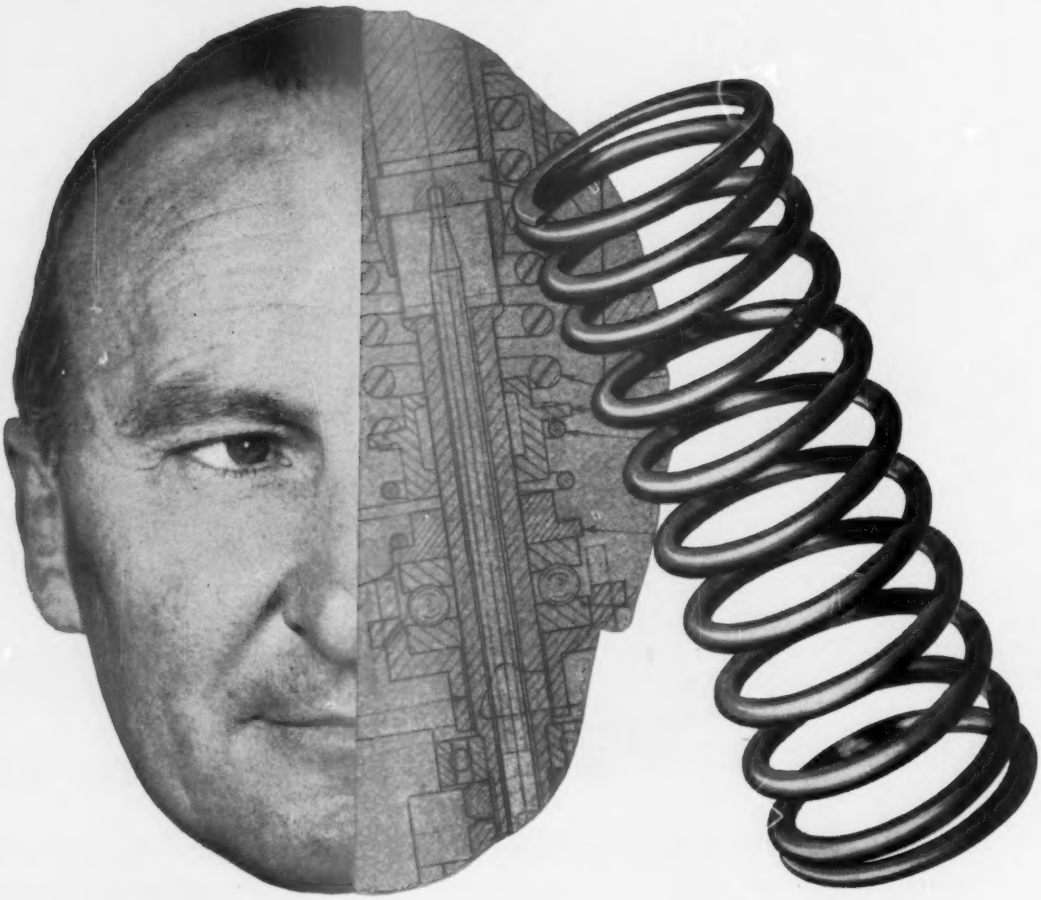
Write for list of members and publications describing the properties and uses of die castings to:—

ZADCA

ZINC ALLOY DIE CASTERS ASSOCIATION

34 Berkeley Square, London, W.1. Telephone: GROsvenor 6636

SALTER ...



...always a spring ahead!

Think of springs and you think of Salter.
Think of Salter and you think of springs that do their job
and go on doing it long after you expect them to.
We are as determined to uphold our reputation for dependability
as you are to buy the finest springs the trade
can produce—whether they are made to your specification
or designed by our own specialists.

GEO. SALTER & CO. LTD., WEST BROMWICH, ENGLAND
ESTABLISHED 1760

To most great names in industry

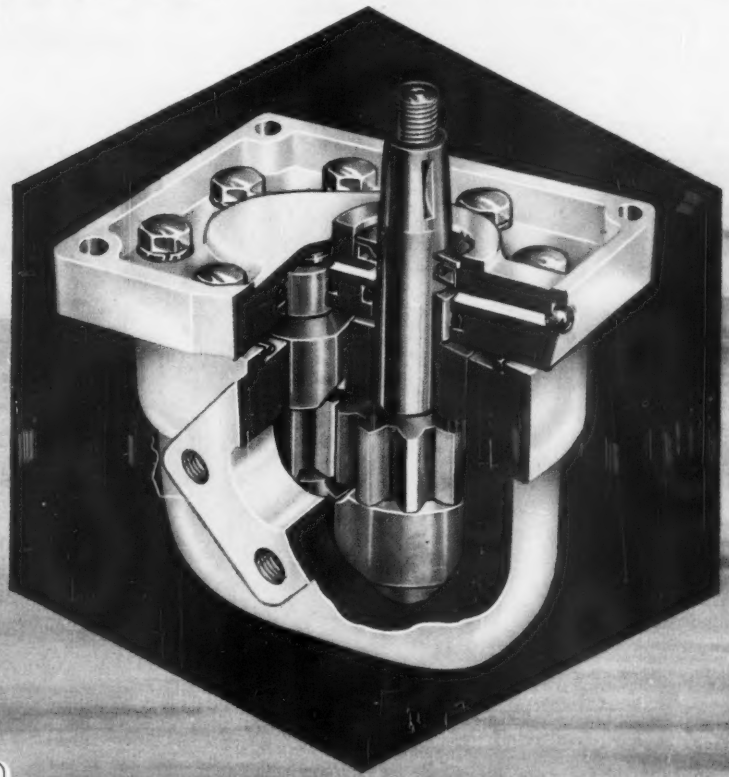
HYDRAULIC POWER

means Plessey pumps

An ever-increasing number of design engineers throughout the world specify the Plessey Hydraulic Pump. Here is the reason. The advanced design incorporates patented pressure-loaded bearings. These unique bearings automatically ensure minimum end clearance and maintain a consistently high level of efficiency. The pump provides a high-pressure rating with a volumetric efficiency of over 90 per cent.

These pumps are providing hydraulic power for many types of agricultural equipment, road vehicles and materials handling equipment. Easily installed and extremely versatile, there is a pump in the Plessey range to provide hydraulic power for every normal requirement. If you have a problem which involves hydraulic power, get in touch with Plessey—they may well be able to provide the answer—simply, efficiently and economically.

PATENTED
BALANCED
PRESSURE-LOADED
BEARINGS

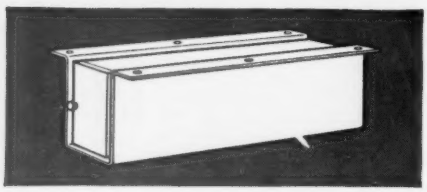


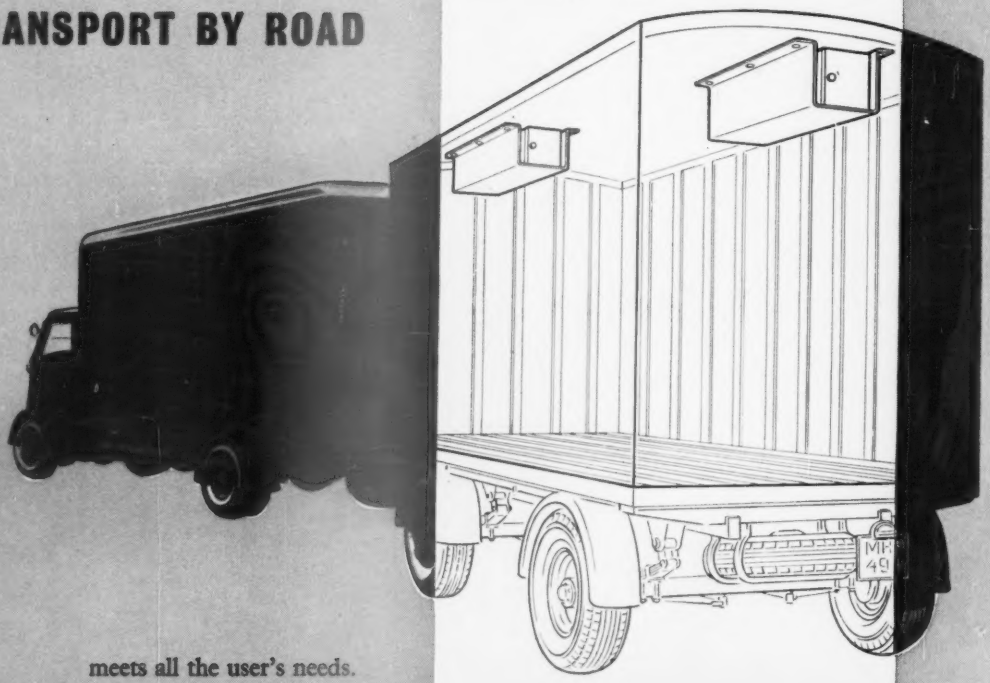
Plessey Hydraulic Pumps, Valves and Rams

AIRCRAFT AND AUTOMOTIVE GROUP · INDUSTRIAL HYDRAULICS DIVISION
THE PLESSEY COMPANY LIMITED · CHENEY MANOR · SWINDON · WILTSHIRE

HP11

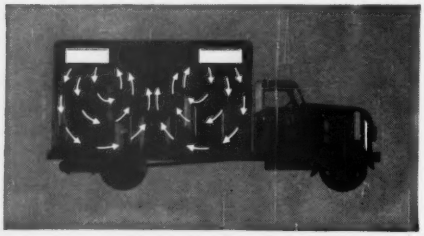
'DRIKOLD' REFRIGERATION FOR TRANSPORT BY ROAD





meets all the user's needs.
'DRIKOLD' does not reduce the payload ;
is simple and inexpensive ;
does not require skilled operation
or maintenance ;
is completely reliable in operation ;
is hygienic and free from mess.

Full technical service is offered.



Before ordering or building Refrigerated Vehicles look into the outstanding advantages of 'DRIKOLD'

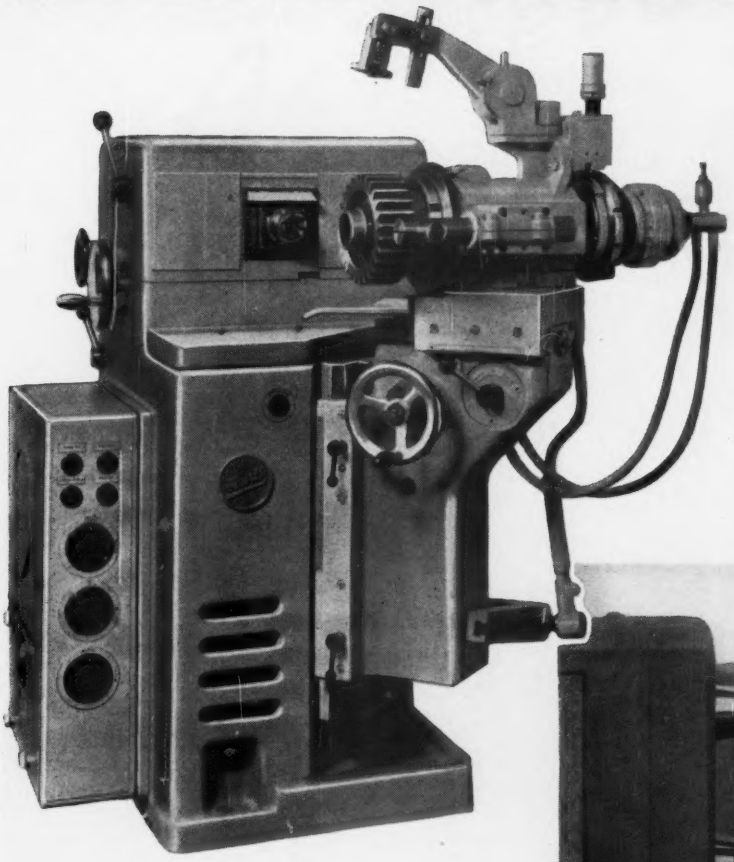
'DRIKOLD' **the solid carbon dioxide—dry ice—sold by Imperial Chemical Industries Ltd.**

Enquiries to :
IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

ICI

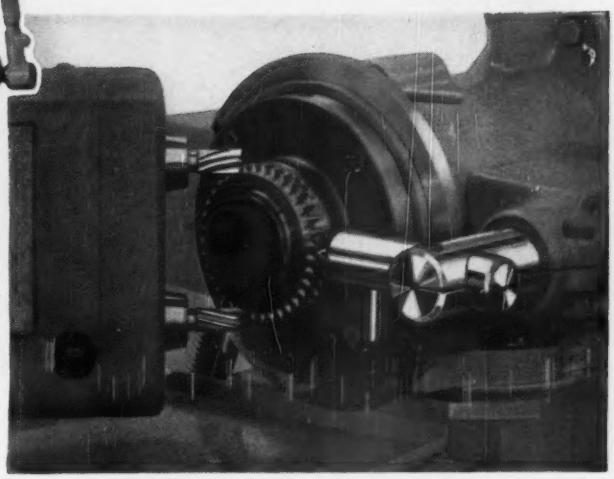
DK.230

Hurth AUTOMATIC



GEAR TOOTH ROUNDING & DE-BURRING MACHINES

TWO-SPINDLE HEAD AVAILABLE FOR VOLUME PRODUCTION



Fast approach of bell-type cutter, self indexing after reaching pre-set depth and automatic stopping on completion of cycle, make the HURTH Model ZK4 an ideal machine for batch work on spur and helical gears, starter rings, clutches, etc. Maximum work-piece dia.: 12". Range of teeth rounded : chamfered or de-burred 25-6 D.P., 7-110 teeth per gear. Speeds up to 120 teeth per minute.

See latest developments at 5th. European Machine Tool Exhibition, Hanover Sept. 15-24.

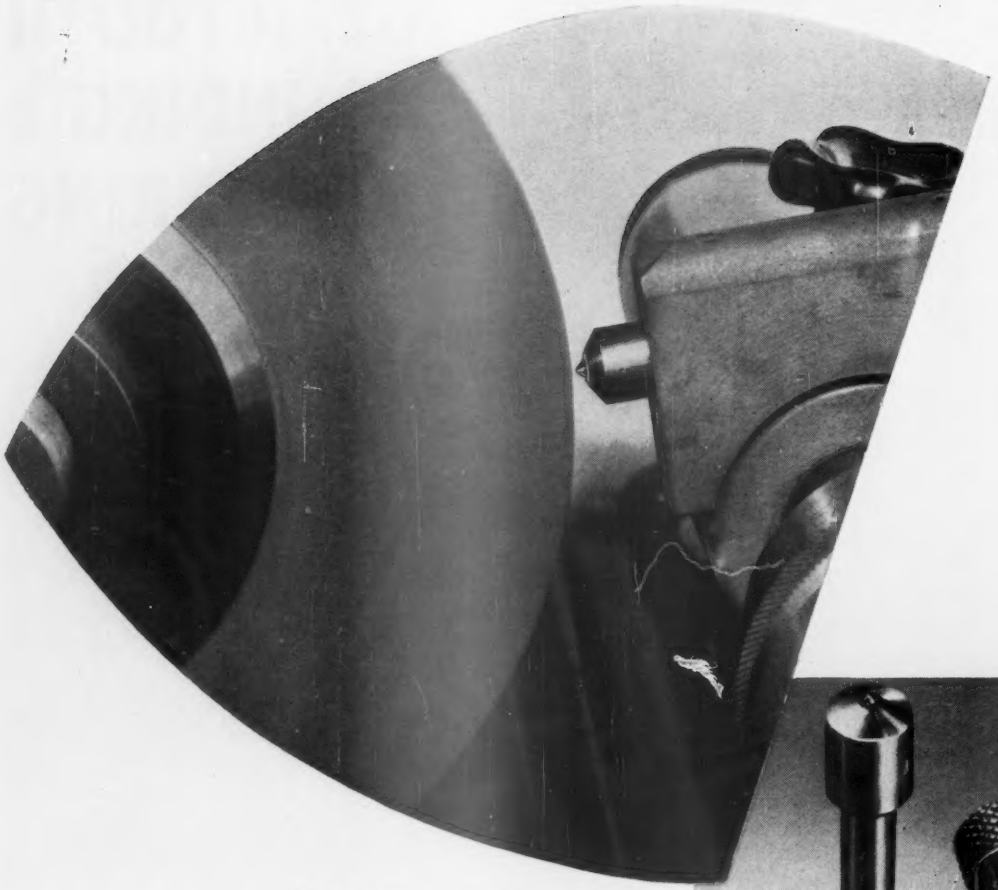
VAUGHAN ASSOCIATES LIMITED

4, QUEEN STREET, CURZON STREET, LONDON, W.1
Telephone : GROSVENOR 8362-5

Midland Office: WILFORD CRESCENT, NOTTINGHAM
Telephone : NOTTINGHAM 88008.

DIAMOND
cut
DIAMOND

We use our own products



For accuracy and good finish on our own jigs and fixtures for diamond tool production the toolroom equipment includes a fully universal precision grinding machine. For truing plain cylindrical wheels on this machine we use Diatru tools

LM VAN MOPPES & SONS (DIAMOND TOOLS) LTD
BASINGSTOKE · HAMPSHIRE · ENGLAND

TELEPHONE: BASINGSTOKE 1240
TELEGRAMS: DIATIPT BASINGSTOKE

OUR ILLUSTRATED DATA SHEETS AND OUR TECHNICAL REPRESENTATIVES ARE AVAILABLE ON REQUEST

J.W.2

BEST BRAKES IN THE WORLD

Achievement!

DISC BRAKES
ON RACING CARS

FACTS

ASTON-MARTIN • LOTUS • COOPER • LISTER

The makers of these world famous racing cars fitted GIRLING DISC BRAKES to ensure their successes in PRODUCTION, SPORTS CAR, FORMULA II and LIBRE events at—

Sebring · Spa · Reims
Rouen · Le Mans · Chimay
Nurburgring · Silverstone
Goodwood · Aintree
Oulton Park · Brands Hatch
during 1956.

GIRLING
DISC BRAKES
NOW being tested on

BRITISH RAILWAYS

GIRLING
THE BEST BRAKES IN THE WORLD

Makers of hydraulically operated DISC BRAKES since 1940

'way out ahead'

GIRLING LIMITED · KINGS ROAD · TYSELEY · BIRMINGHAM 11

.... British-made
HEALD BOREMATICS
and
INTERNAL GRINDERS

for which we are sole agents, are now being made in England by Heald Machines Ltd., a British company.

The initial machines being produced are:—

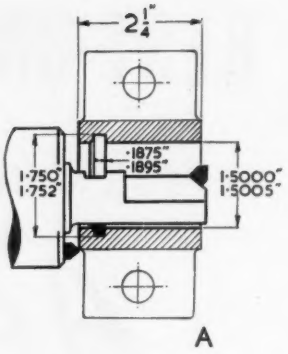
No. 271 Internal Grinder which is suitable for precision grinding to extremely close tolerances on roundness and diameter and with a finish as fine as one micro-inch, on work up to 12" outside diameter.

The **Gagematic and Sizematic** types are automatic in operation except for chucking and unloading; the machine automatically stops when the required size is obtained.

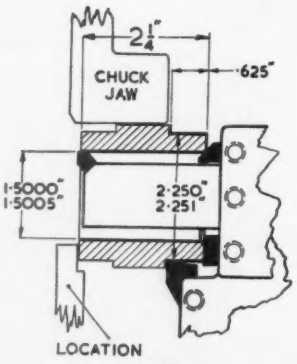
The **Plain** machine is semi-automatic and suitable for medium production runs where automatic sizing is not required.

Minimum hole ground ⅛" diameter.

Maximum hole ground 5½" diameter × 5" long (Sizematic and Gagematic) 7½" diameter × 8" long (Plain).

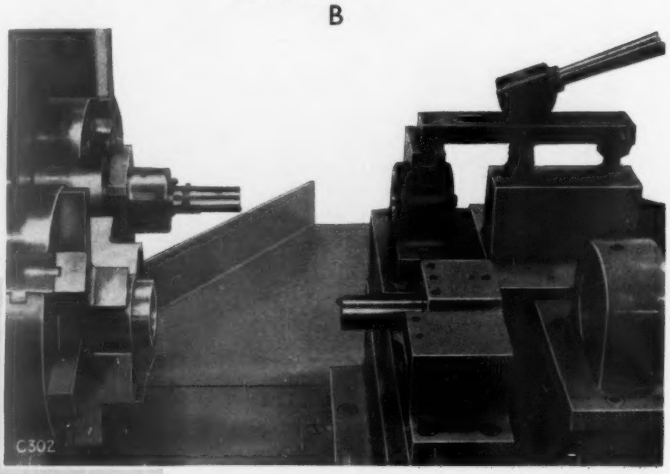


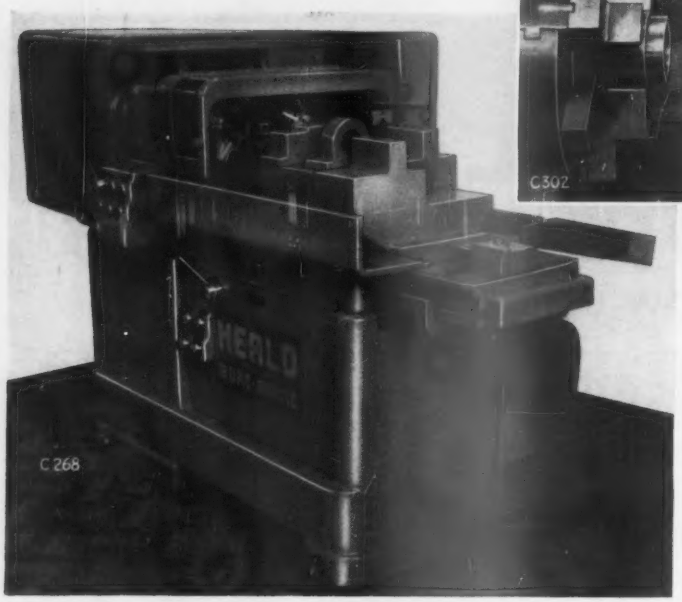
A



B

No. 221 Single-end and No. 222 Double-end Borematics. A universal machine yet equally suited to single-purpose, high-production operation. Each head can be set to perform a separate operation on a single part—straight, spherical or taper boring, facing and turning. Work or tooling can rotate. Many work stations.





The Heald No. 221 Single-end Machine tooled for simultaneous operation on stationary (A) and rotating (B) workpieces.

A.—*Operations on a gun-metal housing. The boring head carries the boring bar and the cross feed facing and recessing unit.*

B.—*A brass bush held on the boring head, is bored, turned, chamfered and faced by tools carried in a boring bar held on the table.*

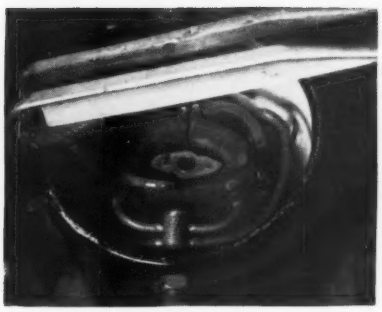
ALFRED HERBERT LTD. COVENTRY

FACTORED DIVISION, RED LANE WORKS

AD 180

AUTOMOBILE ENGINEER

CONTENTS



ON THE DELCO-REMY IGNITION DISTRIBUTOR THE CAM ASSEMBLY IS INDUCTION-HEATED IN A FIXTURE AND QUENCHED. THERE IS AUTOMATIC EJECTION TO THE RAILS ABOVE

211 Editorial *Exterior Decoration*

212 American Motors V-Eight Engine R. Burkhardt *A new design that is readily adaptable to increases in capacity and output*

221 Centralized Spare Parts Service *An important development by Ford Motor Company Ltd.*

224 Infra-Red Equipment for Paint Drying *Metrovick sheathed-type elements in standard units or specially shaped forms*

229 Abarth Record-Breaking Cars *Two vehicles based on Fiat and Alfa Romeo chassis with bodies designed and styled by Pinin Farina*

232 Testing Friction Materials N. Carpenter *A discussion of development practice in the laboratory and on the road*

244 Automatic Flame-Hardening *Adaptable machines for continuously controlled operation in the production line*

250 Delco-Remy Ignition Distributor *Notes on basic design and production*

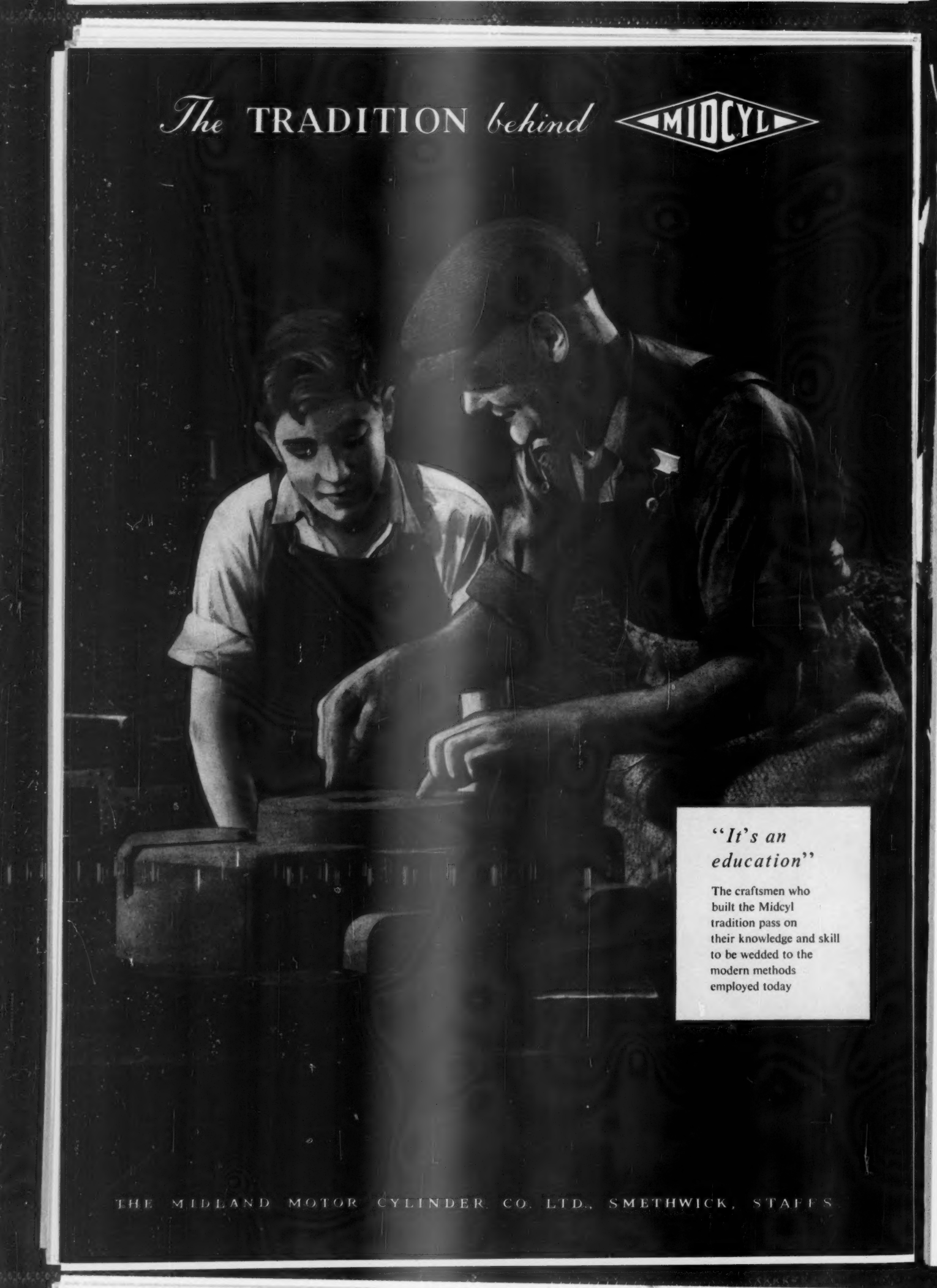
253 Bendix Electrojector *An electronically-controlled and electrically-actuated petrol injection system*

255 Current Patents *A review of recent automobile specifications*

Published the second Wednesday in every month
by ILIFFE & SONS LIMITED
Dorset House, Stamford Street, London, S.E.1.
Telephone · Waterloo 3333 (60 lines)
Telegrams · Sliderule, Sedist London.
The annual subscription inland and overseas is £2 17s. 0d. including the special number
Canada and U.S.A. $8·50

BRANCH OFFICES
Coventry · 8-10 Corporation St.
Telephone · Coventry 5210
Birmingham 2 · King Edward House, New St.
Telephone · Midland 7191-7
Manchester 3 · 260 Deansgate
Telephone · Blackfriars 4412
Glasgow, C.2 · 26B Renfield St.
Telephone · Central 1265-6

The TRADITION *behind* MIDCYL



"It's an education"

The craftsmen who built the Midcyl tradition pass on their knowledge and skill to be wedded to the modern methods employed today

THE MIDLAND MOTOR CYLINDER CO. LTD., SMETHWICK, STAFFS.

Editor J. B. Duncan

Editorial Staff T. K. Garrett, A.M.I.Mech.E. A.F.R.Ae.S.(*Associate Editor*)

F. C. Sheffield

DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Exterior Decoration

AN independent survey carried out by the American Iron and Steel Institute to determine car owners' desires on the matter of exterior decoration produced results that should be of interest to the British automobile industry. The survey revealed that more than 40 per cent of the motorists who were questioned were prepared to pay extra to have exterior parts in the material they thought best, and of these, 57 per cent favoured stainless steel. Furthermore, 35 per cent expressed a preference for less decoration than is used on new models, while only 4·7 per cent desired more.

The amount of decoration is, of course, a matter of taste —or, perhaps, lack of taste—but whether little or much is used, it is important that the finish should not quickly deteriorate. Unfortunately this is not true of a lot of the chromium plating used on modern vehicles; hence the increasing application by owners of protective coatings to chromium plated parts on new cars. Whether the solution lies in the use of better quality plating on mild steel or in the use of some other material is worth thought.

This problem is not, of course, peculiar to the British automobile industry. It is one with which manufacturers in all countries have to contend. Therefore, it is of interest to consider trends in the United States of America. There, increasing use is being made of stainless steel for components previously produced in chromium plated mild steel. For various reasons, this development is much less marked in this country than in the U.S.A. Nevertheless, at least one British model now incorporates stainless steel in quantities approaching American standards.

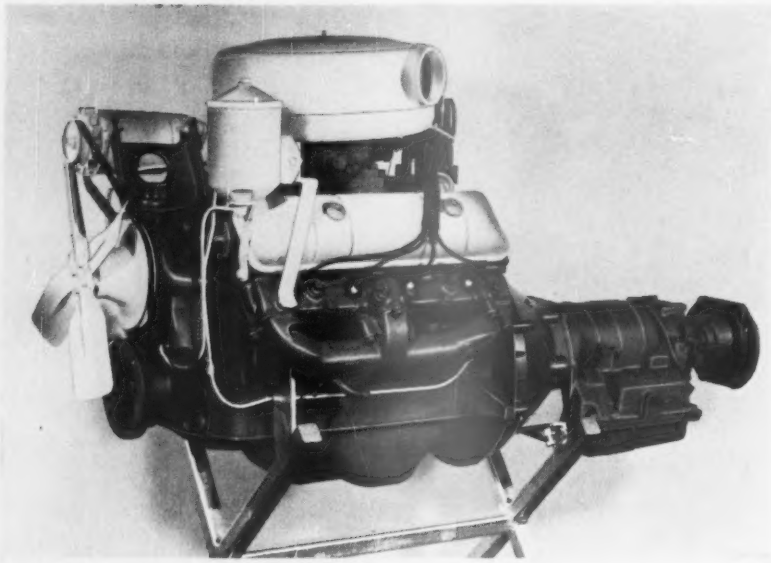
Of the total U.S.A. production of stainless steel sheet and strip, the automobile industry in that country takes almost one-quarter, that is in the order of 100,000 short tons, mainly strip. A recent survey of 1957 American cars shows that Chrysler use 28 lb per car, General Motors 33 lb, Studebaker-Packard 25 lb and Ford 35 lb. The greatest use of this material per car is on the 1957 Cadillac "El Dorado", which has no less than 85 lb of stainless steel, including a polished steel roof.

Comparable figures are not available for the British automobile industry. It is however, estimated that not more than 2,000 tons are used annually by the industry in this country. This gives a figure of two pounds per vehicle. So low a figure in relation to American usage does not necessarily mean that the industry is opposed to the use of stainless steel. The fact is that until very recently the output of British stainless steel sheet and strip was relatively small, and any increased utilization would have entailed high cost imports from America. Now, however, the picture is altered and the steel industry is in a position to meet the full demands of the automobile industry for both stainless steel sheet and strip.

The chief advantage claimed for stainless steel is that its resistance to corrosion is greater than that of chromium plate. This is, of course, important, but there are also other advantages. It is, for instance, much harder than the non-ferrous metals and is therefore, more able to withstand knocks and dents, which on chromium plated articles can lead to the onset of creeping corrosion once the plate is damaged. This capacity to withstand rough usage is particularly important for components such as bumpers, hub caps and wheel discs, which are regularly subject to hammer from grit and stones thrown up from the road surface during the passage of the vehicle. Furthermore, stainless steel can be kept bright and new looking merely by washing—not an unimportant point since it affects both the amount of time and labour that must be spent on the car and also the secondhand value.

However, so far as manufacture is concerned it is the price factor that will be decisive. Admittedly, a chromium plated mild steel component will normally be cheaper than one in stainless steel of the same gauge, but although stainless steel costs more per ton it can be used in lighter gauges. For example, hub caps can be produced in stainless steel as thin as 0·018 in and yet be as cheap, lighter and stronger than conventional mild steel plated caps.

In the U.S.A. at least 40 per cent of the stainless steel used in the automobile industry is either 18/8 or the slightly cheaper 17/7 austenitic stainless steel. In general, these qualities are used for parts such as wheel discs, hub caps, grilles and lamp bezels which are relatively near the road, that is, in the worst position for damage. Type 430 (17 per cent chromium), which is virtually the only one employed by the automobile industry in this country, is used in America mainly above the waist and frequently in the cold-formed condition without any further polishing. However, it must be stated that it is doubtful whether the strip now being produced in this country can quite match the high finish obtained in America. Even so, there should be no necessity for expensive polishing operations to bring stainless steel parts up to a satisfactory finish. There may, of course, be the objection that stainless steel parts will not match the colour of other parts that are chromium plated, and for this reason some manufacturers have made a practice of giving a chromium plate flash to stainless steel parts. This, however, seems to be unnecessary, since while there may be a perceptible difference under the bright lights of a showroom, it would be imperceptible, except to a very practised eye, in normal daylight. It is not without interest that both Ford and Chrysler in America have decided to cease chromium flashing stainless steel, at least on their cheaper models.



American Motors has designed this V-eight engine for the Rambler, which is one of the smallest and lightest passenger cars on the American market. Another version of the engine, the cylinder block of which is cast with a larger core, is employed in the Nash Ambassador and Hudson Hornet

AMERICAN MOTORS V-EIGHT ENGINE

A New Design that is Readily Adaptable to Increases in Capacity and Output

R. BURKHARDT

AMERICAN MOTORS CORPORATION is the last of the passenger car manufacturers in the United States to design and market its own V-eight engine. American Motors delayed work on a V-eight unit in the expectation, and the hope, that there would be a revival of interest in six-cylinder engines because of their lower cost and greater fuel economy. No such revival of interest has occurred. In fact, car-buyer preference continues to move in the other direction, with less concern for economy and increasing acceptance of higher and higher horsepower V-eight models. As a result, American Motors found itself in an untenable position, competitively, without a V-eight engine to offer its customers.

About four years ago design work was started on a V-eight engine and an interim arrangement was made with Packard to offer that company's new V-eight as an optional engine on American Motors' luxury line of cars, the Nash; and, after consolidation, the Hudson. To the company's surprise, there was even a demand for V-eight engines in its cheaper line of cars, the small Rambler series. Since the Packard V-eight would not fit in the Rambler, all that could be done was gradually to increase the horse-power of the in-line six-cylinder Rambler engine from 82 b.h.p. in 1951 to 125 b.h.p. (135 b.h.p. optional) in the 1957 model.

Nevertheless, there was still a demand for V-eight power in the Rambler and the designers were instructed to develop a basic V-eight for use in the small cars; equally important, it had to be a V-eight which could also be manufactured in a higher horsepower range, without resort to such artificial devices as supercharging, for the luxury Nash and Hudson line. Apart from the fact that development of a new engine, which occurs only rarely in these days of great capital costs, is always of interest, the unusual requirements of flexibility which had to be met by the American Motors designers make this V-eight particularly notable.

Since American Motors makes one of the smallest and lightest passenger cars on the American market, the Rambler, this new V-eight is offered in a basic form, known as the 5720 model, which has a capacity of 250 in³ with a twin-throat carburettor, capable of developing 190 b.h.p. at 4,900 r.p.m., and 203 b.h.p. with an optional four-barrel carburettor. For Hudson and Nash applications, the engine is built to produce 255 b.h.p. at 4,700 r.p.m., with a four-barrel carburettor. In this form, the unit is known as the 5780 model. The added power is obtained by increasing the internal core sizes of the block to allow a change in bore from 3·5 in, in the 5720 model, to 4·0 in. By virtue of the use of identical cylinder heads for both displacement sizes, the compression ratio is also increased from 8:1 to 9:1. The stroke of 3·25 in is the same in both models.

The design and tooling for this engine cost upwards of $20 million, a major capital outlay for the company. In

SPECIFICATION

	5720	5780
Type	90 deg V-shape	
Number of cylinders	8	
Valve arrangement	Overhead	
Bore	3·5 in	4·0 in
Stroke	3·25 in	
Piston displacement	205 in³	327 in³
Compression ratio	8:1	9:1
Maximum b.h.p.	190 or 203*	255
at r.p.m.	4,900	4,700
Maximum torque	240 lb/ft or 253 lb/ft*	345 lb/ft
at r.p.m.	2,500	2,600
Oil pressure	55 lb/in²	
at r.p.m.	3,400	
Engine cooling system	21 quart pressure	20 quart pressure

**Optional, four-barrel carburettor*

order to write off such costs, this basic engine will have to be useful to American Motors, allowing for minor improvements and changes, for at least ten years. This fact was an important consideration to the designers, who found time pressing hard on them, with competitors offering V-eight engines of ever-higher horsepower ratings. As a consequence, this engine is being produced in three different horsepower ratings in the first year of use:

1. A Rambler V-eight with 250 in³ displacement. This model, the 5720, has solid valve lifters and an 8:1 compression ratio.
2. A Nash-Hudson model of 327 in³ displacement, the 5780, equipped with hydraulic valve lifters and a 9:1 compression ratio.
3. A Rambler Rebel model of 327 in³ displacement, solid valve lifters and a 9·5:1 compression ratio.

These last two engines are modifications of the basic 5720, 250 in³ engine. According to the designers five considerations were kept uppermost in mind in working up this basic new V-eight:

(1) High performance characteristics, which would equal or surpass competitive V-eight engines.

(2) An engine design flexible enough to be adaptable to future displacement and horsepower requirements, compression ratio changes and such other new developments or improvement as might have to be included.

(3) An engine easily installed in present-day bodies and in those that may be developed in the next few years, and one that would also lend itself to repetitive production assembly.

(4) An engine readily accessible for service.

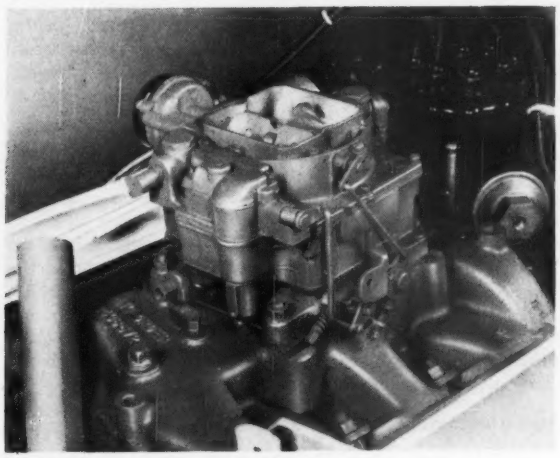
(5) An engine of the lowest weight possible without sacrifice of performance or durability.

High performance

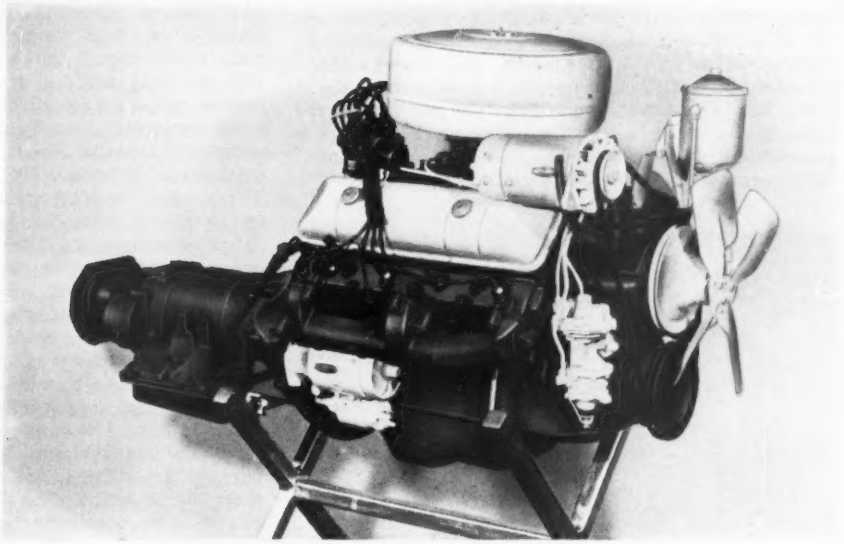
Buyers in the current American automobile market seem readily willing to pay a premium for cars with ample, if not excessive, power reserves. To meet this customer-demand, the larger manufacturers have been accused by some critics of engaging in a "horsepower race" with new models of increased horsepower offered each year. In the case of the Rambler, appeal is made to those buyers who are seeking economy, along with a reasonable high level of performance. The 250 in³ V-eight engine is an optional power unit (an in-line six-cylinder engine with 195·6 in³ displacement and 125 b.h.p. is standard power in the 1957 models) intended for the buyer who wants added performance and is prepared to accept some loss in economy. With an 8:1 compression ratio the designers recommend use of standard gasoline, which sells for 3 to 5 cents less per U.S. gallon. A power reserve of more than 50 per cent in the engine ensures such desirable features as fast getaways at the traffic light and a quick response to acceleration demands, even on hills.

This basic engine is designed to suit a capacity greater than that now used. In this connection, the designers state that value sizes were determined by future breathing requirements, as were both the inlet and exhaust ports. Furthermore, the crankshaft forging is suitable for considerably heavier reciprocating and rotating stresses than are now present, and the water and oil pumps have a greater capacity than is currently required. The cylinder centre distance of 4·75 in is considerably larger than necessary for the 3·50 in bore, and is intended to allow for increases without sacrificing cylinder wall cooling. Main bearing caps and bolts, and connecting rods have also been designed for greater load carrying capacity in the future.

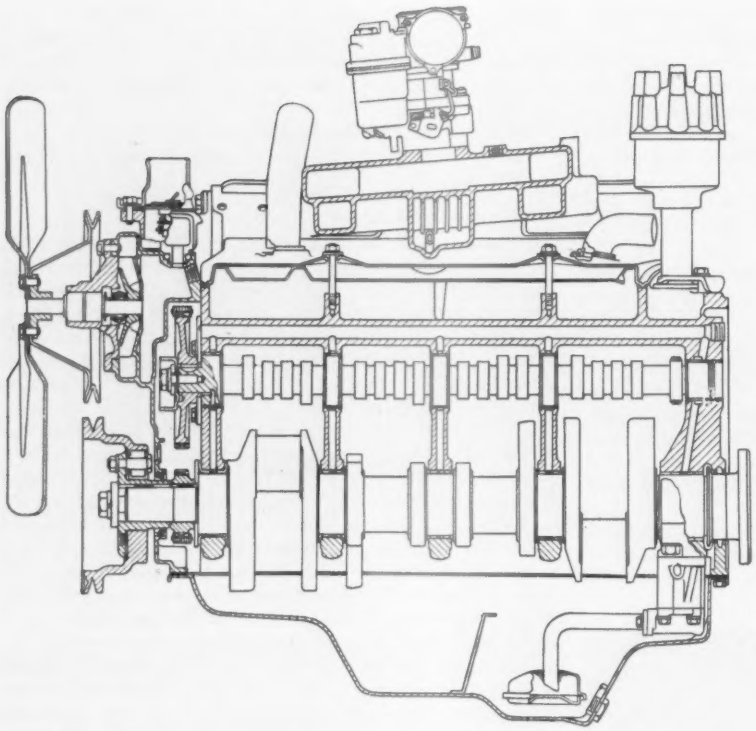
From a production standpoint, it is expected that increased engine displacement can be obtained without extensive or expensive tooling changes. Crankshaft balancing equipment need only be recalibrated while no changes are needed on the block other than pattern and machining alterations. With



Carter dual-throat carburettor used on the 250 in³ version of the American Motors engine

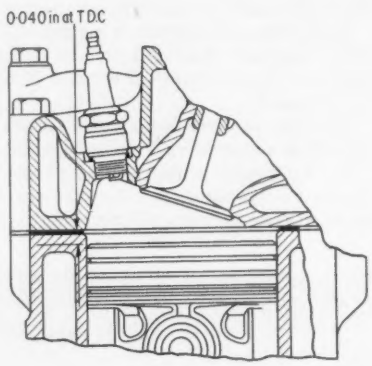


Right-hand side of the engine, showing the arrangement of the auxiliary units. The air cleaner, which is of large size, fits snugly over the carburettor



Longitudinal section of the engine, showing the general layout. The eccentric that actuates the fuel pump is secured to the front face of the half speed wheel

Cross section of the combustion chamber illustrated at the foot of this page

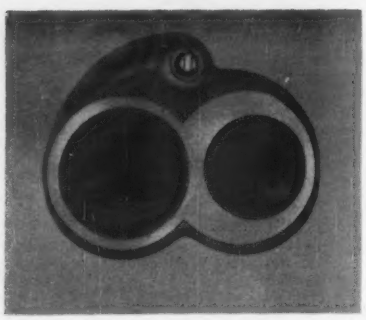


valves designed for greater displacement, the only change needed in the cylinder head to increase horse power is in the form of the cast combustion chamber.

Engine size

Envisaged increases in engine displacement can be effected without changing the overall size. To suit the body styling and to facilitate assembly and installation, the engine was kept as compact as possible. In order to reduce height and width, a short stroke of 3·25 in was decided upon, with the crankshaft counterweights carefully contoured to further shorten the distance from the crankshaft centre-line to the top of the block. Exhaust manifolds are carried below the port openings in the head, and the intake port facings are held parallel to the cross sectional centre-line of the cylinder banks to further reduce the height of the carburettor flange.

By these means it was possible to design an engine with a width of 24⅛ in across the exhaust manifolds, and a height from the crankshaft centre-line to the carburettor flange of 14 5/16 in. The overall length from the rear face of the engine to the centre of the fan pulley is 27 23/32 in. It is expected that these dimensions will remain unchanged even if engine displacement is increased.



The combustion chamber is cast in such a way that it requires a minimum of machining

A compact V-eight presents some servicing problems. Measures were taken to overcome these as far as possible. Spark plugs are located well above the exhaust manifolds, and are in a nearly-vertical position for easier removal and installation. Service consideration is the main reason for locating the generator at the upper right-hand side of the engine, and outside the tappet cover, for easier accessibility. In addition, the distributor has a tongue length, for mating with the oil pump shaft, which allows this engagement to be made prior to engagement of the distributor gear with the camshaft drive gear.

Manufacturing

During the development stage of the engine, the designers maintained exceptionally close liaison with the manufacturing staff. As a result, many economies in fabricating and tooling processes were built into the original design, and have since been carried through into production. Production facilities are completely new for this V-eight and are based on a process called segmented automation. In this method of process engineering, each basic section of the engine line is completely automatic, that is, in materials handling, positioning, etc., but is not fully integrated with other sections. This allows increased flexibility since each portion of the line can be utilized independently of other operations.

The cylinder block boring equipment has an unusual degree of flexibility, in that it will simultaneously finish blocks of two different bore dimensions. It contains two sets of roughing, finishing and chamfering tools, and blocks of either bore size can enter the equipment in any sequence. Each station is set to tool one size bore, and when a block enters that station, an automatic probe determines whether or not to engage the cutting heads.

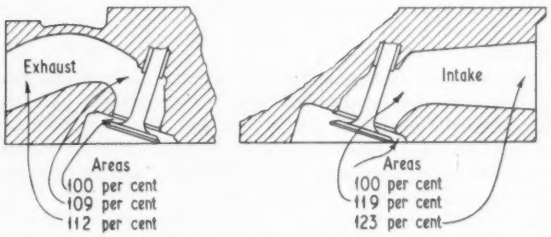
Efforts to hold down the height and length of this engine to an absolute minimum have also aided in limiting the weight. In addition, the designers carefully investigated every design detail to see if further weight reduction was possible. In considering the loading and stressing of parts,

components had to be judged not only on their usage in the present engine, but also in relation to future usage. As a result, even though the weight of the present production engine compares favourably with competitive power plants, the designers state that the advantage of their weight-saving programme will be much more apparent in future versions of the engine.

Cylinder block and crankshaft

The cylinder block is the most important factor determining power-plant size, weight, performance, and flexibility. Therefore, the most careful attention has been given to cylinder block design. To provide inherent stiffness and a good oil sump sealing flange, the crankcase flange has been carried 2·75 in below the crankshaft centre-line. The flywheel housing mounting surface provides a wide and deep base for the drive train mounting, and the 30 cylinder head bolts are patterned to carry the combustion pressure load evenly into the water jacket walls rather than into the cylinder bores. This arrangement is intended to reduce distortion and consequent abnormal wear of the bores, pistons, and piston rings.

Weight saving has been effected in several ways. Working from the bore-to-bore distance of 4·75 in, determined by future displacement needs, the overall length of the block is held to 23·02 in by careful attention to coolant and loading needs. Windows have been cast in the main bearing webs where strength requirements permitted and pockets have been cast on either side of the rear flange for further weight conservation. In the right-hand pocket, the starter motor is mounted close to the crankcase, This allows the starter

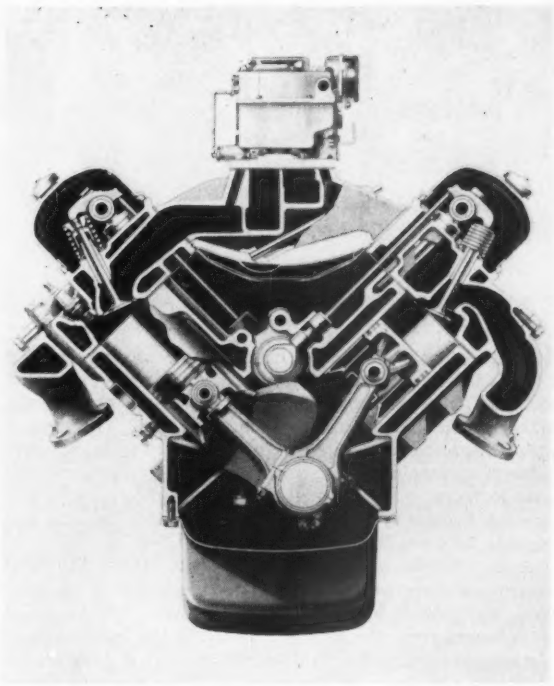


Inlet and exhaust port areas

to be fastened to a lightweight die cast aluminium flywheel housing. By this method, several machining operations for the starter pad normally found on the block are eliminated. In addition, a considerable amount of cast iron is eliminated. The designers estimate that a saving of approximately 15 lb of metal has been realized on the rear of the block alone.

A manufacturing saving has also been effected in this engine by eliminating hard sand cores for casting operations through substitution of green sand wherever possible. Green sand has been specified for the front, side, top and tappet chamber sections and hard sand cores only for the crankcase, bores, water jackets and rear face. All cores are machine set to minimize breakage.

There is widespread disagreement among automobile engineers in America, over what constitutes the best combustion chamber configuration. In this engine, the designers have developed what they call a kidney-shaped, wedge-type, cast chamber. A similar chamber has been used for some years on American Motors' six-cylinder engine, with good results. Since it is cast, the chamber requires a minimum of machining and volume can be located at the most desirable point. The kidney-shape gives a swirling action to the inlet gases for better turbulence and mixing. There is no shrouding of the valves and a high volumetric efficiency is claimed.



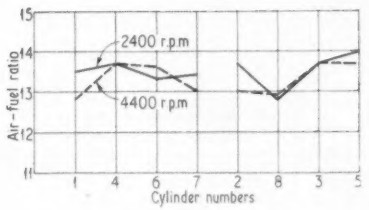
Transverse section of the American Motors V-eight engine

Combustion characteristics are such that the chamber shape acts to control the rate of pressure rise and to minimize engine harshness. The compression ratio of 8:1 was chosen for this basic Rambler V-eight to allow the use of regular fuel with consequent economy of operation. The spark plugs are cooled by the considerable volume of water directed around them. They are shrouded in such a way as to minimize the drowning effects of unvaporized fuel during cold starts.

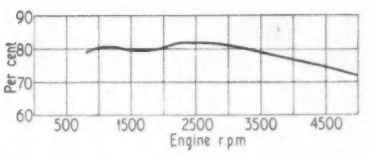
Considerable bench testing was done before the present inlet and exhaust passage system was decided upon. Numerous cold and hot starting tests, as well as extended runs under varied operating conditions, were made by the design engineers to obtain a satisfactory manifold configuration. An accompanying figure shows the air:fuel distribution to the various cylinders with a dual-throat carburettor standard on the basic 5720 engine, for the Rambler.

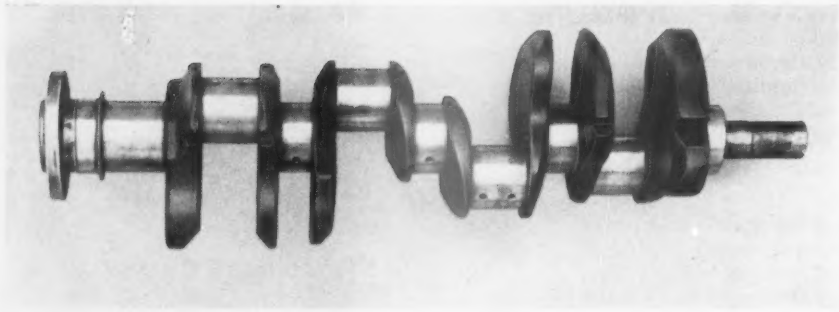
The intake port progressively decreases in diameter towards the valve. It is stated that the slight restriction in

Air:fuel ratios



Volumetric efficiency at full throttle





The crankshaft has been specially designed to allow engine height to be kept to a minimum

flow and consequent increase in gas velocity tends to develop a ram effect at the valve with a resultant increase in engine torque. The valve size is such that gas velocity through the valve is lower than for any competitive engine. The exhaust ports have also been designed to give balanced areas. To give efficient scavenging and to minimize back pressure, the port size increases progressively away from the valve. The exhaust manifolds are designed to be ample in area and provide for a smooth, continuous exhaust flow.

A drop forged, steel crankshaft is used. It has five main bearings and six balancing counterweights, and is the same for both models. It weighs 62·8 lb and has a shaft length of 27·2 inches from the flywheel flange to the front edge of the sprocket shaft. A journal overlap of 0·75 in provides for increased stiffness. All the counterweights are cam turned fully to realize every possible reduction in engine height. In addition, the cheeks are chamfered to allow the contoured skirts of the pistons to nest closer to their crank pins when at bottom dead centre. This in turn allows a shorter connecting rod length and further reduces engine height. Depressions are cast in the bottom jacket walls of the cylinder block to allow for clearance of the counterweights. Rubber-and-friction type damping is used to reduce all orders of frequency within the engine speed range to negligible amplitudes.

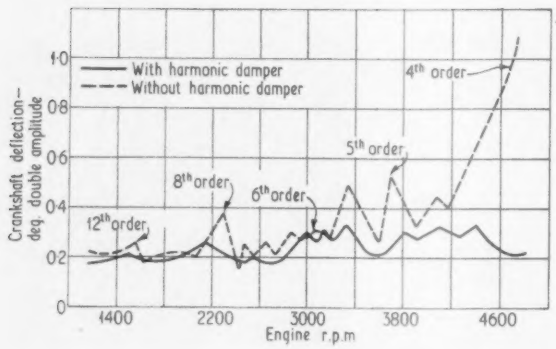
It is reported by the designers that a particularly interesting problem in the design of the engine centred around the balancing of the crankshaft. The forging, itself, had to embody enough inherent balance control to take care of future displacement requirements. However, at the same time it could not have more over-balance when used with the engine under discussion, than the balancing equipment could remove. Reciprocating and rotating weights, or what are more commonly referred to as bob weights, were carefully calculated for all contemplated displacements prior to the final approval of the crankshaft design. This design was made in such a manner that no tooling changes will be needed prior to the initial balancing of the crankshaft itself. For engines with displacements of over 250 in³, a very minor resetting of the balancing equipment is all that is needed.

Initial balancing of the machined crankshaft consists of drilling two 1⅜ in holes into the faces of both the number 1 and number 8 cheeks. This reduces the over-balance of the crankshaft to a value of 7·5 ounce-inches in a predetermined plane. The crankshaft is then assembled in the engine with connecting rods, pistons, gudgeon pins, piston rings, flywheel and crankshaft pulley attached. This assembly is then corrected for the 7·5 ounce-inch left by the initial balancing, plus variations due to the weight and balance tolerance of the attached parts. The correcting is effected by drilling two $\frac{11}{16}$ in holes radially into the periphery of numbers 1 and 8 cheeks, with the location and depth of the holes varying according to the amount of correction needed. This final operation balances the engine assembly to within a maximum tolerance of plus or minus ½ ounce-inch.

Bearings

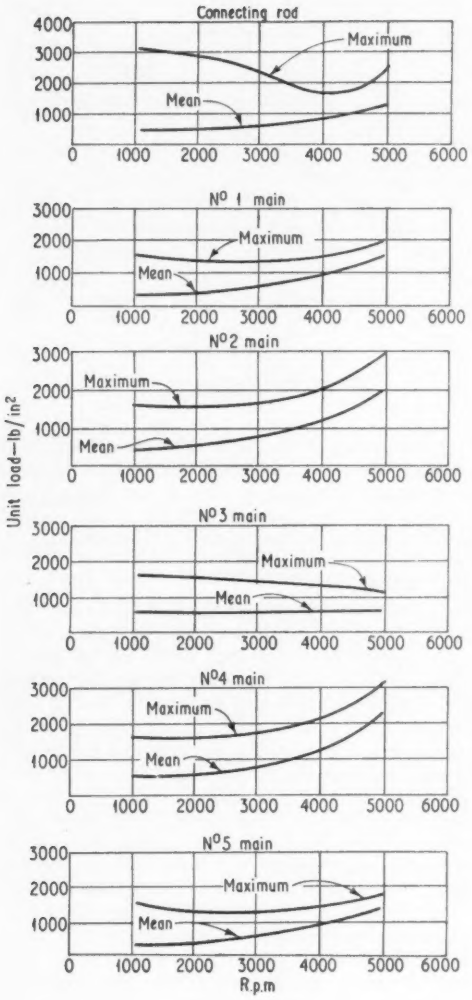
Bearing interchangeability is designed into the engine for reasons of economy and assembly simplicity. All five main bearing diameters are 2·499 in and, with the exception of the front one which is flanged to take crankshaft thrust, they are interchangeable. The effective bearing area for the intermediate and rear main bearings is 2·20 in², while that of the front is 2·08 in². Full 360 deg grooving is used to make the bearing halves similar, and also to assure an adequate flow of oil to the connecting rod at the time of registration for cylinder wall lubrication. Connecting rod

Crankshaft torsional vibrations



CONNECTING ROD AND CRANKSHAFT ASSEMBLY

	5720 and 5780 engines
Connecting rods	
Material	Steel forging, S.A.E.1145
Weight	27·6 oz
Centre-to-centre length	6·375 in
Bearing material	Steel-backed micro-babbitt
Bearing effective length	0·867 in
Clearance	0·0007–0·0028 in
End-play	0·004 –0·012 in, two rods
Crankshaft	
Material	Drop forged steel
Weight	62·8 lb
Vibration damper type	Rubber and friction
End thrust taken by	Bearing No. 1, front
Crankshaft end-play	0·003–0·007 in
Number of journal bearings	Five
Bearing material	Steel-backed micro-babbitt
Diametral clearance	0·0006–0·0032 in
Journal diameter	2·4983–2·4990 in
Effective bearing length	
Front	0·956 in
Remainder	0·950 in
Crank pin diameter	2·2483–2·2490 in



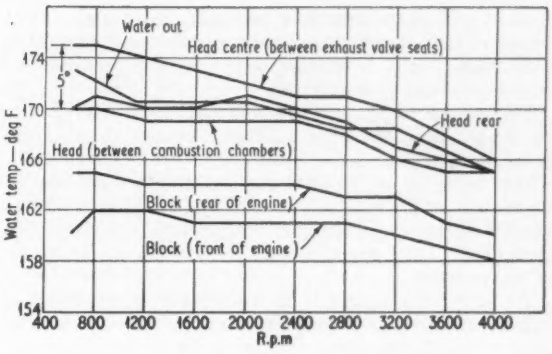
Bearing loads

bearing halves are also the same throughout. The bearing diameter is 2·249 in, and their effective area is 1·935 in². All bearings are of micro-babbitt with steel backs. Maximum and mean loads carried over the engine speed range are shown in an accompanying diagram.

Water flow within the engine has been designed to give complete coverage to all the various parts and temperature variations of the coolant are kept to a minimum. Complete jacketing of the cylinders provides cooling for the entire length and circumference of the bores. A single, high-capacity pump provides the flow. This pump contains a 4 in diameter plastics impeller and is centrally-mounted at the front of the engine. A drilled bypass is provided in the water manifold for circulation during cold starts and prior to the opening of the thermostat. As a result, this engine has relatively low heat rejection characteristics and high thermal efficiency, with a corresponding reduction in needed radiator capacity.

Lubrication

Lubricant is picked up by the fixed screen inlet and drawn into the pump which contains sintered iron gears and is an integral part of the rear main bearing cap. This type of design gives a pump located well up towards the crankshaft



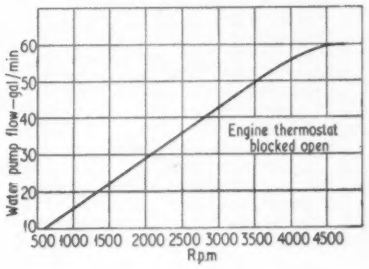
Coolant temperature variations

centre-line and allows placing the oil pan sump in a number of possible locations. This in turn allows great flexibility in locating the steering linkage. The pump is driven through a tongue-and-groove connection with the distributor shaft, and is provided with an oil pressure relief valve. Normal oil pressure is 55 lb/in² at 3,400 r.p.m.

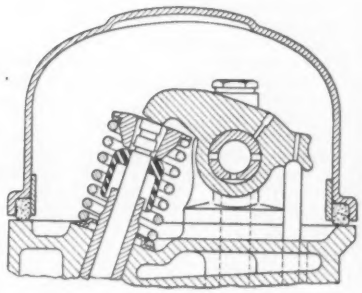
From the pump, the oil is forced through the filter and into the main oil gallery. Flow is then down to the $\frac{7}{64} \times \frac{5}{16}$ in annular grooves machined in the camshaft bearing webs, and thence to the main bearings. Except for oil fed to the camshaft bushings, the main bearings are supplied before any oil is bled off to another location. This assures that the bearings furthest from the pump receive adequate lubrication. There is intermittent lubrication of the chrome plated fuel pump eccentric. This timed squirting of the eccentric occurs when holes drilled in the front camshaft journal register with the camshaft bushing oil hole. At this time oil under pressure is forced through a $\frac{3}{32}$ in diameter hole in the camshaft sprocket, and on to the pump eccentric. This same spray lubricates the timing chain and, in addition, oil is picked up by the cast-in dam on the front cover and directed to the crankshaft sprocket.

For the larger model, equipped with hydraulic lifters, oil is fed through longitudinal galleries that intersect the lifter bores. These galleries are fed from the main gallery through

Water pump capacity



Rocker arm lubrication



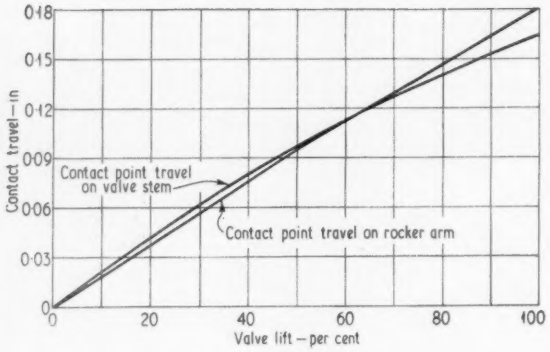
grooves cast in the cast iron camshaft thrust plate. The designers say that no lifter pump-up problems have been encountered, so it is not necessary precisely to meter the flow of oil to the lifter galleries.

The hollow rocker arm shafts in each bank receive their oil supply from the lifter galleries, through short drilled holes in the cylinder head and rocker arm support bolts. These bolts are set in over-size drilled holes and the oil moves around the bolt to the rocker shafts. This movement of oil is at the rear of the engine to provide continuous flow through the lifter galleries and thus prevent the formation of sludge traps.

An interesting approach has been made to the matter of valve stem lubrication during cold starts. The rocker arms have a milled flat, which intersects the oil feed hole; this flat tends to break the surface tension of the cold oil oozing from the feed hole and causes it to flow freely to the valve end of the arm. Tests have shown that the time required to get oil to the valve stem during cold starts has been reduced more than 75 per cent from previous designs. This milled flat also causes hot oil to spill over the sides of the arm and prevents the oil from running down and over-lubricating the valve stems. Oil-resistant, synthetic rubber deflectors are fitted to the valve stems to prevent excessive oil being fed to the valve guides. These deflectors move with the valve stem, and allow an oil mist to lubricate the stem and guide

VALVE DATA

	5720	5780
Valve gear		
Hydraulic lifters	No	Yes
Special provision for valve rotation	No	
Rocker ratio	1·5:1	
Operating tappet clearance, inlet	0·012 in hot	Automatic take-up
Operating tappet clearance, exhaust	0·014 in hot	Automatic take-up
Tappet clearance for timing, inlet	Open 0·18 in. Close 0·0225 in	Zero lash
Tappet clearance for timing, exhaust	Open 0·0195 in Close 0·024 in	Zero lash
Valves		
Inlet valves;		
Material	Silicrome 1 or XB	
Overall length	4·827 in	
Head diameter	1·787 in	
Angle of seat	30 deg	
Angle of valve face	29 deg	
Stem diameter	0·3412–0·3417 in	
Clearance in guide	0·0013–0·0028 in	
Valve lift	0·375 in	
Spring pressure and length, valve closed	85–91 lb at 1 13/16 in	
Spring pressure and length, valve open	150–160 lb at 1 7/16 in	
Exhaust valves;		
Material	Head and upper stem S.A.E. 2112N, lower stem S.A.E.3150 or 8645	
Overall length	4·827 in	
Head diameter	1·406 in	
Angle of seat	45 deg	
Angle of valve face	44 deg	
Stem diameter	0·3407–0·3412 in	
Clearance in guide	0·0018–0·0033 in	
Valve lift	0·375 in	
Spring pressure and length, valve closed	85–91 lb at 1 13/16 in	
Spring pressure and length, valve open	150–160 lb at 1 7/16 in	
Valve timing;		
Inlet opens	12 deg 30 min B.T.D.C.	
Inlet closes	51 deg 30 min A.B.D.C.	
Exhaust opens	53 deg 30 min B.B.D.C.	
Exhaust closes	10 deg 30 min A.T.D.C.	



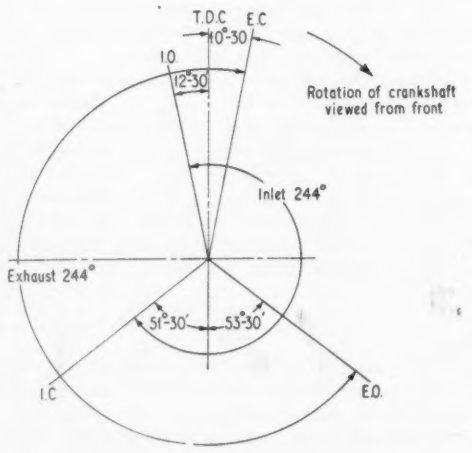
Rocker arm geometry

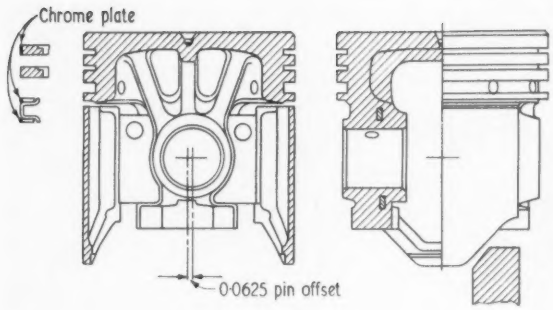
when the valve is closed. Distributor lubrication is supplied through a drilled hole in the distributor body, which registers with the right-hand lifter gallery. Oil is fed through the distributor body into the distributor bushing and carried to the gears by means of internal grooving in the bushing.

Pistons and rings

Following previous American Motors practice, this V-eight uses aluminium alloy, steel insert, Autothermic pistons. The pistons have slippered skirts, are tin plated, and have the gudgeon pin boss holes bearingized after plating to assure an accurate bearing area for the pin and to help prevent scuffing. The pistons are of the double-slot design and have three vertical ribs joining the head and pin bosses. These ribs support the bosses and tend to reduce deflections during the periods of high pin loading. The slipper type skirt is shaped to match closely the contoured counterweights of the crankshaft when the piston is at bottom dead centre. This serves to reduce further the necessary height of the cylinder block. To allow for use with compression ratios well above 8:1, the piston head is 0·25 in thick. An 0·0625 offset of the piston pin toward the major thrust face is intended to give maximum freedom from piston slap. The piston finished weight is 511 grams and balancing lugs allow for 31 grams of weight control. Three rings are employed. The two compression rings are of alloy iron, $\frac{5}{64}$ in wide with the top ring having a 0·004-0·007 in thick, lapped chrome plating. The oil control ring is composed of three pieces: two rails and a spring steel spacer. The

Valve timing diagram





Piston and rings

reacting faces of the rails are chrome plated to a minimum depth of 0·0025 in, and buffed.

Valve gear

American Motors and its Nash-Hudson predecessors, have had nearly 40 years of experience with valve-in-head engines and many of the design considerations reflect this. The camshaft is of alloy iron with five bearings. It is chain-driven. All lobes carry a 15 maximum micro-inch finish and the cams are ground to a 0·001-0·002 taper per in. This latter, together with spherical lifter faces and offset centre-lines, are intended to ensure positive lifter rotation. The lifter bodies are hardenable iron, with a face hardness of 54 Rockwell C and are lubrited for improved break-in. Case hardened steel pushrod sockets are used.

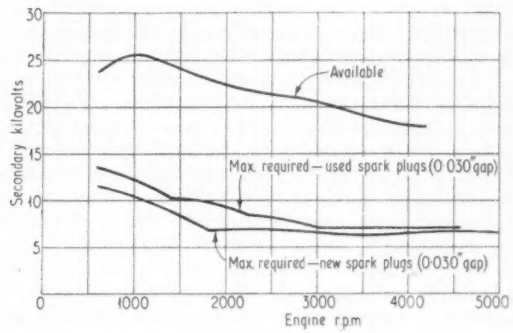
The diameter of the lifter is 0·904 in, allowing an effective diameter of 0·900 in when the centre-line offset, spherical face and tapered cam lobes are considered. This value is well above the 0·800 in diameter necessary to keep the edge of the tappet face from digging into the cam lobe. The 0·800 critical diameter is computed from cam lift velocity. There is ample space to utilize cam contours with more severe lift velocities. Critical pump-up speed for these tappets has been found to be well over 5,000 r.p.m. maximum engine speed.

The solid push rods used on the Rambler engines are 0·25 in diameter, and are made of S.A.E.1060 cold drawn steel, hardened to a minimum of 50 Rockwell C. An overall length of 8·87 in assures a rigid valve train component. The rocker arms are of cast pearlitic, malleable iron. They are as short as possible to further reduce valve train deflection. To help reduce scuffing of the rocker shaft the arms are lubrited after finishing. The rocker arm geometry has been established to give a minimum amount of slip between the arm and the valve stem tip during periods of high loading. This high loading period occurs at the point of greatest lift acceleration. On this cam, the greatest lift acceleration occurs just before one-fifth of the lift takes place. The movement of the contact points along the rocker arm and the valve are shown in an accompanying diagram; the vertical gap between the curves represents slip.

Silchrome 1 steel is used for the inlet valves, which have 1·787 in diameter heads and 30 deg seat angles. The exhaust valves are of two-piece construction, with the head and upper stem made of S.A.E.2112N steel and the exhaust valve head diameter is 1·406 in. Both valves operate with a moderate 0·375 in lift. Because of the relatively large valves used, timing can be held to conservative values. A top centre valve overlap of only 23 deg has proved to be ample for high-speed breathing and "high end" performance. This small overlap gives the engine good idling characteristics and "low end" output.

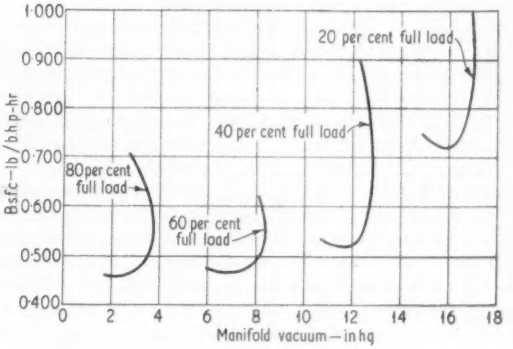
PISTON ASSEMBLIES

	5720	5780
Pistons		
Material	Aluminium alloy, with steel insert	
Type and finish	Slipper skirt, tin plate, Autothermic	
Weight of piston only	18·0 oz	23·45 oz.
Clearance at top land	0·020 –0·024 in	
Clearance at top of skirt	0·001 –0·0015 in	
Clearance at bottom of skirt	0·0009–0·0015 in	
Compression rings		
Number	Two	
Material and finish	Alloy iron; top, periphery chromium plated; second Ferrox	
Gap	0·010 –0·020 in	
Face width	0·0775–0·078 in	
Radial thickness	0·175 in	
Depth of groove in piston	0·1835–0·1905 in	
Oil control ring		
Number	One	
Material and finish	Spring steel, Perfect Circle '98'; periphery chromium plated, remainder black oxide	
Gap	0·015–0·055 in	
Face width	0·0245 in each rail	
Radial thickness	0·156 in	
Depth of groove in piston	0·1855–0·1925 in	
Location of expanders	Between ring rails	
Gudgeon pins		
Material	S.A.E.1016 steel	
Length	3·187 in	
Diameter	0·9305–0·9308 in	
Location	Locked in rod	
Bushing in rod or piston	None	
Clearance in piston	Palm press fit	
Clearance in rod	Press fit, locked	
Direction of offset in piston	0·0625 in towards major thrust side	



Ignition reserve

Part-throttle fuel requirements at 2,400 r.p.m.

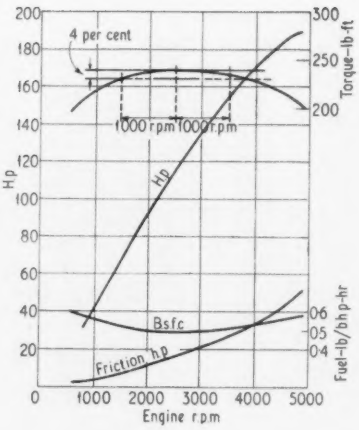


Electrical system

This is the first new engine introduced since the American car manufacturers standardized on the 12-volt system two years ago. As a result electrical components are designed to take advantage of the higher voltage. Spark plug leads have been kept short and carried well above exhaust manifold heat to make the system as efficient as possible. The distributor is mounted on the right-hand side of the engine to obtain an upward thrust and makes a thrust washer unnecessary.

A considerable amount of ignition reserve is available in the engine with both new and worn spark plugs. The high spark advance setting and the moderate 8:1 compression ratio are both factors adding to this reserve. The designers state that it is their experience that this relationship of voltage available to voltage required definitely improves cold starting and helps reduce the ill effects of spark plug gap increases and deposits.

Full throttle performance



Performance

A diagram is given to present the performance characteristics of this new engine. The full throttle gross performance curves were obtained in dynamometer tests using best power fuel and spark advance, an 8:1 compression ratio, and corrected to standard S.A.E. conditions. As noted, peak b.h.p. figure of 190 is obtained at 4,900 r.p.m. The friction horse power curve shows results of the relatively short stroke design, minimum practical weight of moving parts, in that it reaches a value of only 34 b.h.p. at 4,000 r.p.m. It will be seen that the specific fuel consumption curve shows a low rate over the entire speed range and a minimum value of 0·485 lb/b.h.p-hr. Fuel curves are given to show the carburettor flow requirements of part-throttle operation at 2,400 r.p.m.

Finally, the torque curve is a significant indication of the engine's performance in road service. It would appear from this that the engine has a relatively flat torque curve and a differential from the peak of only 4 per cent in the engine speed range of 1,500-3,500 r.p.m. The maximum torque of 240 lb/ft is obtained at 2,500 r.p.m.

These notes are based in part on a paper presented by John F. Adamson, Carl E. Burke and David Potter at the National Meeting of the Society of Automotive Engineers in Detroit, Michigan. The use of the photographs and permission to quote from the paper have been granted by Messrs. Adamson, Burke and Potter, the American Motors Corporation and the S.A.E. are gratefully acknowledged by the author.

Rear Engine Vehicles

AMERICAN ideas on rear engine cars were presented by two speakers at a recent National Passenger Car, Body and Materials meeting of the Society of Automotive Engineers. On the question of styling, one speaker said that public acceptance of the rear-engined car is related to psychological factors such as the degree of collision protection afforded to the driver of such a car, the amount of passenger space which the public has been led to believe can be made available, and the handling characteristics of the vehicle. The development of rear-engine car styling will, it is considered, be a transitional process. Since passengers will be placed within the wheelbase, a front bonnet will be retained, but, with elimination of the front-mounted radiator, it can be made lower to improve driver vision. Improved vision should be achieved at the driver's eye level; glass roofs are not favoured. Maximum interior space and comfort will be sought by designers, with exterior lines devised to reduce the appearance of bulbousness. Bright-metal decoration should be used with discretion on vulnerable parts.

Basic problems in the design of a rear-engined car are concerned with: (1) the passenger-seating space; (2) suspension and handling; (3) chassis-frame design; (4) power-unit design, and (5) manufacture and servicing. Consideration of a number of current and recent rear-engine designs (Volkswagen, Renault, Fiat, Isotta-Fraschini and the American Paxton project) indicates that, in general, such vehicles have inadequate luggage or rear-seat space, and that a full-sized, rear-engined car requires a wheelbase of at least 120 in. To achieve adequate stability, the weight on the rear wheels should not exceed 60 per cent of the total under the worst loading conditions. Automatic suspension-levelling devices will help considerably in making a rear-engine location practicable. Greater front-suspension travel will be required, but the need for an understeering front-end geometry will allow continuation of low roll centres in front, which will ease the geometry problems inherent in increased suspension travel. Some form of independent rear suspension is essential. A slight amount of oversteer, combined with a reasonable polar moment, may possibly be desirable.

Chassis-frame problems in a rear-engined car do not differ appreciably from those of conventional cars. The Volkswagen, Renault and Fiat chassis, consisting of pressed-steel underpans, the platform-type Isotta-Fraschini chassis, and the "torque-box" Paxton chassis and its trailing-arm front and rear suspensions with steering-controlled camber angle are typical. Lighter engine-transmission units will be required for future rear-engined cars; aircraft-quality gears, light alloys, unconventional cylinder arrangements, exhaust-jet-assisted air cooling, and lighter accessories are possible approaches to the problem. The Paxton vehicle employed a four-cylinder, eight-opposed-piston, two-stroke engine in conjunction with a belt-drive automatic transmission.

Substantial reductions in manufacturing, though not in tooling costs, are possible with integral body-chassis construction. Integration of the engine and transmission can cancel or outweigh the cost of independent rear suspension, and installation of the unit on the assembly line is cheaper than with conventional engine-transmission arrangements. The engine can be made either more accessible or readily removable from the vehicle for servicing. Though the cost may be higher of the light-weight engine-transmission unit necessary for a rear-engined car, this will not, it is considered, affect adversely the commercial success of the vehicle.

The headquarters and depot of Ford Spares Division

CENTRALIZED SPARE PARTS SERVICE

An Important Development by Ford Motor Company Ltd.

IN their £65,000,000 modernization and expansion programme Ford Motor Company Ltd. have given priority to a depot equipped to deal with all spares for British-made Ford cars, commercial vehicles, tractors and industrial units for this country and for overseas. That this project has been given priority is a measure of the importance that the company attaches to service for users of Ford products. The depot is located at Avely, Essex, some eight miles from the main manufacturing plants at Dagenham.

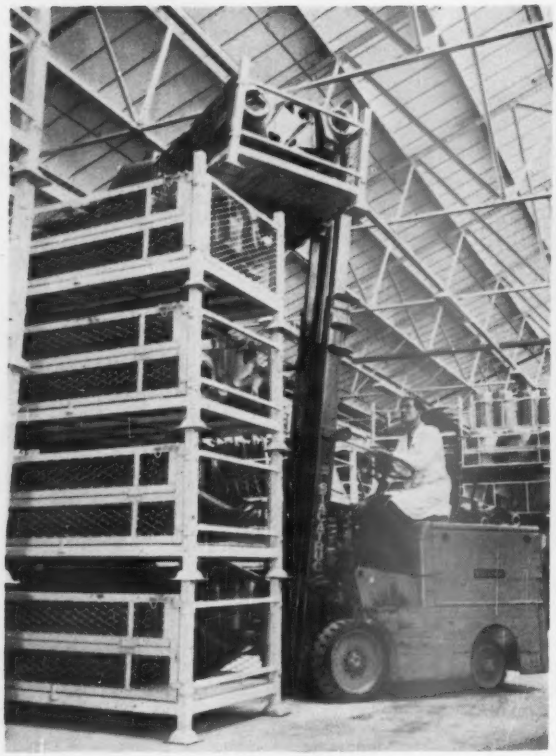
Hitherto, the company's spares organization operated mainly from four different locations in Southern England, and used a number of warehouses, in locations ranging from Southampton to Doncaster, for storing parts. It then took from two to four weeks to deal with a British dealer's monthly restocking order, while routine orders from overseas took from four to five weeks. Now, with all the clerical work and parts storage centralized at Avely, routine British orders can be cleared in seven days and bulk orders from associated Ford companies and dealers overseas can be handled within three weeks, a period that will shortly be reduced to two weeks. In addition, the depot will soon be operating a 24-hours' despatch service for emergency parts for immobilized vehicles and for urgent overseas orders, which are sent by air-freight.

In this new depot stocks are carried of over 31,500 different items, and some 4,000,000 orders will be dealt with in the course of a year. About 400 people are employed in the offices and about 800 in the warehouse. To spread the work-load evenly in both the offices and the stores, every British Ford dealer has a stated day for submitting his monthly restocking order. When the order is received, it is duplicated in a pack of pre-punched cards. Each card is punched to show the item, the quantity required, the price and the exact location of the part in the warehouse. These cards are fed through Powers-Samas machines which tabulate invoices at the rate of 80 lines of part numbers and other details per minute. One copy of the invoice goes to the warehouse to be used as an order note by the operative who "picks" the parts detailed on it; a second copy is retained in the offices for reference; the third goes to the dealer as an advice note to confirm the order.

Essentially, the warehouse comprises a receiving section, four main storage sections, two packing sections and a shipping section. There are, in addition, a carton store and a case-making section. Of the four main storage areas, the first is for small items such as nuts and bolts and gears. These items are stored in tiers of bins. Items that are too heavy or bulky for the light bin section—such as axle housings, gearboxes and bumpers—are located in the second section, which has 60 tubular pallet racks. Sheet metal body parts, glass, upholstery and radiators are stored in post pallets with timber decking in the third section, while accessories are stored in the fourth section.

In an organization of this character, materials handling is an extremely important factor. Therefore, a full study, including a survey by four Ford executives of American practices, was carried out on this subject. As a result, it was possible to devise the optimum layout from a materials handling concept and then design the building to suit the layout.

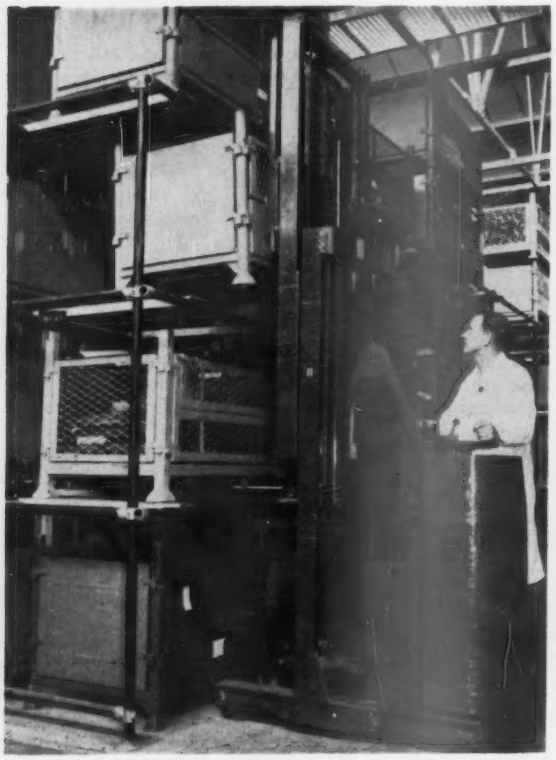
Parts are delivered by road to the receiving section on the east side of the warehouse. In this section there are five double-truck bays with "up-and-over" mechanically-operated doors to conserve heat. Three of the bays have dock-levellers. Each of these is a platform that can be quickly adjusted hydraulically to the height of a truck floor so that the receiving personnel, using electrically-propelled pallet trucks, can unload spares straight across the leveller into the warehouse. As a further aid to unloading, each bay has a 30 cwt travelling hoist. A mechanized anti-rust



A Stacatruc at work in the sheet metal section

Loaded trolleys on the 3,200 ft Towveyor

A Lansing Bagnall reach truck in a narrow aisle



Dock levellers facilitate loading and unloading

system is located in the receiving section immediately adjacent to the bays. An overhead conveyor carries rust susceptible parts through an immersion tank of rust preventive before they are taken to their specified location in the warehouse.

Deliveries from the main Ford plant at Dagenham are made by a fleet of company-owned articulated 4-D Thames vehicles. The trailers, which have reinforced floors, have been specially designed for speedy and easy loading. They are 23 ft long and have a capacity of eight to nine tons. As can be seen from the illustration, the trailer sides have not been enclosed, but when necessary the load is protected from the weather by curtains of thick green canvas which run in Coburn tracking. The curtains can be drawn back to allow side loading in addition to the normal method of loading by pallet truck through the rear opening. The parts are shipped in pallets so that they can be handled in bulk by fork lift trucks and other materials handling aids. After they are unloaded, the larger parts are taken by fork lift truck for storage in pallet racks in the appropriate location. Smaller parts are delivered to their locations on Towveyor trolleys.

Briefly, the mechanical handling equipment used in the warehouse comprises a Towveyor conveyor, seven Stacatrucs, four Lansing Bagnall reach trucks, three powered Yale and Towne Worksaver pallet trucks and eight hand hydraulic Ormic and I.T.D. Portopal pallet trucks.

The Towveyor, which is 3,200 ft long, is one of the first to be installed in this country. It is an under-floor conveyor arranged to tow special trolleys through all the main storage areas at a speed of 80 ft per minute. There are 680 special trolleys for use with this conveyor. Each has a bolt in the nose that can be lowered through the centre of the Towveyor rail to connect with one of the pusher dogs spaced at 20 ft intervals on the inverted monorail conveyor beneath the floor. Four hundred of the trolleys have a capacity of one-half ton. They are wheeled among the storage bins while the parts for an order are "picked." The other 280 trolleys have a capacity of two tons and are used for the heavier and bulkier items. When an order is completed, the loaded trolley is attached to the Towveyor for transfer to the packing and shipping areas.

In order to get maximum storage space from a given floor area, it is now virtually essential to use fork lift trucks. Two types, Stacatrucs and Lansing Bagnall reach trucks, are used at Avely. The Stacatrucs, which operate on electric batteries, have a lift of 14 ft with 36 in centre forks. Each is capable of lifting 4,500 lb at 20 in load centres. The Lansing Bagnall reach trucks have been chosen because they can be operated in relatively narrow aisles. Each of these trucks has a 12 ft lift, a capacity of 2,500 lb, and can be manœuvred in aisles 7 ft wide.

There are two packing sections, one for British and the other for export orders. Both are served by the Towveyor system. After packing is completed, the carton or crate, as the case may be, is transferred by the Towveyor to the shipping section on the west side of the building. This section has five double-truck bays.

The Garrington Constant-Velocity Universal Joint

THE ubiquitous Hooke's joint suffers the disadvantage that it has a relatively limited angle of operation, say 25 deg to each side of a neutral axis, and is incapable of transmitting uniform motion. If a constant velocity is required between the driving and driven shafts, an intermediate shaft must be provided and coupled with a universal joint at each end. Of the numerous types of single-unit, constant-velocity joints that have been evolved, most are, in one respect or another, relatively complicated, costly to produce, or insufficiently robust to sustain heavy and fluctuating loadings with the requisite reliability.

This new constant-velocity joint was conceived and produced experimentally by the Fighting Vehicle Research and Development Establishment of the Ministry of Supply specifically for the transmission systems of military vehicles. It has since been developed and produced by Garringtons Ltd., of Bromsgrove, Worcestershire, and has been tested under arduous conditions by the Establishment.

In its production form, it consists of a pair of identical two-horned forgings, each formed as if from a hollow hemispherical body, with the horns of one extending into the spaces between the like horns of the other. In each face of each horn is arranged an elongated abutment pad, which is free to oscillate in its semi-cylindrical seating and is located by an integral shoulder entered into a groove in the seating. Each pad is retained by a spring clip, one leg of which engages a hole in the forging and the other a hole in the end of the pad.

The axes of the pads are arranged in radial planes at 90 deg to each other, permitting axial displacement of the coupling halves without introducing backlash. When assembled, contiguous pads intersect each other with a lozenge-shaped contact area, which undergoes minimum change during axial divergence of the coupling halves. The joint is particularly suited to vehicle applications as it can be used at angular deflections of 35 deg from the straight.

The Garrington joint is available in a range of sizes to suit shafts from 0·6 in diameter upwards. A 5 in spherical joint for shafts of 1·5-2 in has a rated torque capacity of 5,750 lb/ft and an estimated torque to fracture of 8,500 lb/ft. At 10 deg inclination, the capacity is reduced to 5,000 lb/ft, at 24 deg to 3,750 lb/ft and at 33 deg to 2,750 lb/ft.

The Garrington constant-velocity joint has only three standardized component parts. In total it comprises two forged yokes, eight abutment pads, and eight pad-retaining spring clips

INFRA-RED EQUIPMENT FOR PAINT DRYING

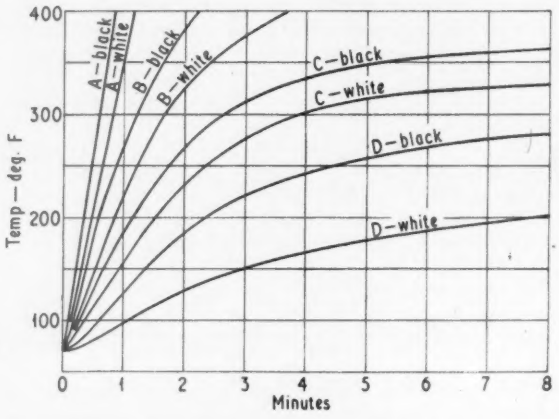
Metrovick Sheathed-type Elements in Standard Units or Specially Shaped Forms

INFRA-RED radiation is neither novel nor mysterious. For practical purposes associated with the use of infra-red equipment in industry, it may be defined as an electro-magnetic radiation which, when it falls on a material substance, causes the temperature of the substance to rise. No intervening medium is required to effect the heat transfer. The term "infra-red" is derived from the position of this particular radiation in the electro-magnetic spectrum. It lies immediately below the visible red in the spectrum and is produced by heat. It is estimated that 50 per cent of the total energy emitted by the sun is in the form of infra-red radiation. In many respects it resembles light, in that it may be absorbed, transmitted, reflected and refracted according to the waveband covered by the radiation and to the physical characteristics of the material receiving it.

When used for stoving paint on metal articles, infra-red radiation is partly absorbed by the paint, thereby directly raising its temperature. Partly it is reflected by the paint surface and partly it is transmitted through the paint film, possibly being refracted on the way. The amount transmitted depends on the specific wavelength of the radiation, the thickness of the paint film and the paint characteristics. That part of the radiation passing through the paint film strikes the underlying metal and may again be absorbed, transmitted and reflected by the metal itself. The absorbed radiation heats the metal and some of this heat will be conducted to the inner surface of the paint film. Any radiation reflected from the metal passes again through the paint film and may be partly absorbed by it. Thus the familiar generalization that "infra-red heats from the inside outwards" is only partly true, but it serves as a convenient comparison with normal convection stoving, which is purely a surface-heating process.

Infra-red radiation is given off by all heated substances, but the intensity of this radiation for a given body is proportional to the fourth power of its absolute temperature. A radiant heat source at, say, 750 deg C will consequently have a high rate of heat transfer to a body at, say, 20 deg C provided the receiving body is not highly reflective. Since the receiving body, in the majority of infra-red heating applications, is not required to be raised to a temperature exceeding about 200 deg C, the rate of heat transfer from a source at 750 deg C will still be high at the end of the heating period.

In an infra-red oven radiation is directed towards the object to be heated by means of reflectors suitably shaped and made of a metal selected for its power to reflect highly radiation within the waveband concerned. These reflectors serve also to re-direct radiation reflected back from the surface of the object. Electricity is advantageously used to run the emitter since it provides complete and direct conversion into heat, has no harmful waste products, is safe in operation, and can be readily controlled. Any temperature can be provided, from the 2,200 deg C of a lamp filament to a black-heat emitter at 500 deg C or less.



Test A: Panel irradiated on both sides by infra-red element projectors having an output of 10 watt/in² of radiating area, located at a distance of 6 in from the panel

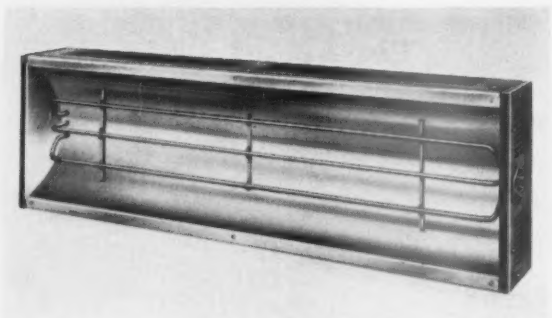
Test B: Conditions as in Test A, but panel irradiated on one side only

Test C: Conditions as in Test B, but distance increased to 17 in to reduce the rate of temperature rise

Test D: Panel irradiated by infra-red lamps at an intensity of 2 watts/in²

Curves showing the effect of paint colour and intensity of radiation on the heating of 18-gauge steel panels

The standardized infra-red projector unit is made in three lengths: 18 in, 24 in and 36 in



The electric lamp, with at first a carbon filament and later with a metal filament, has been used with success in many applications. It has the advantage of being a small mass emitter running at a high temperature, and has a virtually instantaneous response when switched on or off. The major portion of its radiation is emitted over a waveband of from 6,000 to 30,000 Ångström units (Å). It is, however, relatively fragile. Also, in some applications, it is not easy to avoid "spotting" of the work caused by local concentrations of heat. Control is generally possible only in a series of steps, either by the switching of separate banks of lamps or by some form of series-parallel arrangement.

Originally the lamps were installed in either individual or trough reflectors, which in operation in paint-drying ovens soon become tarnished by the volatile elements from the paint and required regular cleaning and polishing in

order to maintain their efficiency. Various metal coatings were applied to the reflectors in efforts to extend the useful period of operation before repolishing became necessary. Nickel, silver, and chrome were used but eventually gold was found to be the most efficient in this respect and became virtually standard practice. A later development was the introduction of the internal reflector lamp. The incorporation of the reflector inside the lamp bulb obviated the tarnishing which had lowered the efficiency of the external reflector.

Sheathed elements

These disadvantages are overcome by the use of sheathed-type elements as the emitting source. They are operated at 750 deg C, at which temperature the infra-red radiation is at a wavelength selected as the best compromise for efficient heat transfer under most conditions encountered in industrial applications. Emission mainly covers a waveband of 12,000 to 80,000Å. Radiation at this temperature corresponds to a peak in the absorption curve for water and furthermore, discrimination between light and dark colours is less marked than in the case of higher temperature radiation.

Since the sheathed element operates at a much lower temperature than the lamp filament, the intensity of radiation is very much lower for a given area of emitting surface. However, the emitting surface of a lamp filament is extremely small and it is possible with sheathed elements to arrange a higher radiation intensity by reason of the much greater surface area of the element and the practicability of pitching adjacent elements much more closely than is possible with lamps. On account of its greatly increased mass as compared with that of the lamp filament, the heating-up and cooling down rate of the element-type emitter is markedly slower. This factor enables a heat output control of the energy regulator type to be used, giving the operator a simple, steplessly variable control.

The Metrovick element is constructed by inserting a tube of magnesium, of 99·9 per cent purity, into an outer sheath of a non-scaling and non-corrodible alloy. A helical coil of high-grade, heat-resisting wire is introduced within the magnesium tube, and the tube is then converted into a magnesium oxide which solidly packs the outer sheath. This oxide ensures the centralization of the wire helix in the bore of the sheath, an even thickness of insulation separating the wire from the sheath and the uniform spacing of the turns of the wire. The outer surface of the sheath is treated to ensure uniform radiation of the heat.

Outstanding features of such elements are robustness, mechanical strength and electrical safety. They will withstand rough handling. The resistance wire, being solidly embedded in the magnesium oxide insulation, is protected from atmospheric corrosion and thus has an exceptionally long life. Mechanically, the element will support its own weight with the minimum number of tie bars or mountings. In the normal installation position the element is arranged horizontally. As the sheath is insulated from the resistance wire it may be earthed to eliminate any danger of electrical shock occurring on physical contact. A specific guarantee of working life cannot be given as the life of the elements depends on many variable factors and a combination of high loading and unsuitable operating conditions may reduce the life appreciably. As an indication, however, the life of a sheathed element may be taken as being in excess of 5,000 hr under average conditions and in some cases lives of more than 10,000 hr have been experienced.

Standardized infra-red projector units are made in three lengths, 18 in, 24 in, and 36 in, found to be convenient for general application and for building up into banks. Standard element assemblies, readily removable and replaceable, are produced in two versions, for D.C. and single phase A.C., and for three-phase A.C., and in two loading capacities for each size of projector. These cover a range of loadings from 1·5 kW to 4·0 kW. A complete projector weighs 13½ lb, 16 lb, and 20 lb for 18 in, 24 in, and 36 in sizes respectively. The element assembly is mounted in a trough-shaped reflector of anodized aluminium sheet supported in a frame furnished at each end with either a clamp or a flange for attachment to a tubular or an angle-iron framing. Standard projectors are cased by perforated side and end panels which are detachable. These panels are omitted from projectors intended for installation in a closed oven.

Paint stoving

In infra-red stoving, such factors as the intensity of radiation on the painted surface, the time of exposure, the mass of the painted component, the waveband of the radiation, the absorption characteristics of both the paint and the underlying surface, will determine the rate of temperature rise and the final temperature attained. For a given article exposed to the radiation from a specific infra-red emitter, the time required to stove the paint film will depend on the ability of the paint to absorb radiation within the waveband

The Briggs infra-red plant at Dagenham for stoving two-tone car bodies. With spray booth, flash-off, oven and vestibules, the overall length is 200 ft

Interior of the 110 ft stoving oven at the Briggs plant. Originally equipped only with vertical projectors for the dark-toned lower part of the body, the addition of overhead projectors enables the light-toned upper part to be stoved

employed. This ability is largely influenced by the colour of the paint.

The graphs of the results of a series of tests show the effect of colour on the temperature rise of painted flat panels of 18-gauge steel. Black paints tend to absorb more of the radiation over a very wide waveband, while a glossy white paint is usually relatively non-absorbent at the shorter wavelengths. Hence, the longer the wavelength the less difference there is in the temperatures attained by panels finished with black and with white paints. From the curves on the graph it will be seen that there is a difference of 80 deg F in the final temperatures recorded for black and white panels when irradiated by infra-red lamps having a peak wave-length of about 1·2μ*. With similar panels irradiated by the Metrovick infra-red elements, operated at 750 deg C and having a peak wavelength about 3·0μ, the difference is reduced to 33 deg F. It will be noted that in the tests different intensities of radiation were employed for the lamps and the elements. This favours the lamps as the lower intensity tends to reduce their difference between black and white.

Additional curves on the graph indicate the effect of increasing the intensity of radiation on the rise of temperature. With a conveyor-type oven it is possible to graduate the intensity of radiation from entry to exit to obtain a desired temperature-time relationship in the article being heated. Commonly, the highest intensity is applied at the entry end to give an initial rapid rise of temperature, the intensity being reduced towards the exit to lower the rate of rise or to maintain the temperature at a specific value. In special cases, however, it may be necessary to reverse the procedure and arrange for an initially low rate of temperature rise. "Wrinkle" paints provide such an example.

Operational safety

Simple precautionary measures are necessary where there is any possibility of low flash point solvents or process products being ignited by the red-hot elements. In most cases it is required merely to provide ventilation adequate to prevent a dangerous accumulation of inflammable gases in the vicinity of the elements when they are at the working temperature. For the drying of cellulose paint, for example, the requirements of H.M. factory inspectors are in general:

1. The spray booth to be located at a distance of more than 20 ft from the infra-red oven.
2. A forced air circulation and exhaust to be provided to keep the solvent accumulation low.
3. Air flow relays to be provided and interlocked with the oven power supply. In the event of a failure of the ventilation system the oven to be automatically cut off.
4. The conveyor drive to be interlocked with the oven power supply. Should the conveyor stop the oven to be automatically cut off.
5. An exhaust hood or duct to extend over the entire length of the plant.

Oven design

So many factors are involved in oven design and so many variables encountered in the size, shape, and mass of the article and the type and colour of the paint, that no standardized designs are available. Instead, each oven is specially designed to furnish the correct heating cycle for a specific product. The fundamental data should in each case be supplemented by time and temperature determinations to ensure a satisfactory design. Metropolitan-Vickers Electrical Co. Ltd., the manufacturers of the infra-red elements, have complete laboratory facilities for such investigations at Trafford Park, Manchester, and at London and can give specialist advice on infra-red stoving problems.

A major advantage to be gained by the use of infra-red heating is a reduction of stoving time, as compared with that of convection heating, by increasing the rate of temperature rise in the article being treated. As a corollary of this facility, the rapid rise of temperature must be controlled by regulation of the time the article is irradiated to ensure that it does not become overheated. Probably the simplest method of control is by the use of a conveyor to pass the article through the area at a selected speed. A conveyor enables each unit length of the article to experience the same amount of radiation and, therefore, assists in the attainment of uniform radiation intensities and temperatures.

It is possible to make efficient use of an infra-red oven for stationary articles if care is taken, particularly with irregular-shaped articles, in positioning and controlling the emitters to obtain uniform intensity of radiation, and if an additional control by time switch is provided. However, infra-red stoving is usually associated with continuous production and normally a conveyor system is incorporated.

A reference was made earlier to the ease with which element-type emitters can be controlled to give a desired output under all conditions. This is effected by means of a

*1μ=10,000 *Ångström units.*

Sunvic variable time-cycle energy regulator which controls the output by varying the period during which the current is "On" relative to the period it is "Off." Cyclic switching of the current "On" and "Off" gives continuous regulation of the average intensity of the infra-red radiation. Variation of intensity is slight due to the thermal mass of the elements and is not of consequence unless the time is very short, say less than 60 sec, and the regulator is set below 75 per cent of full load. No current is wasted and the "On" : "Off" time ratio can be adjusted by movement of a single control knob.

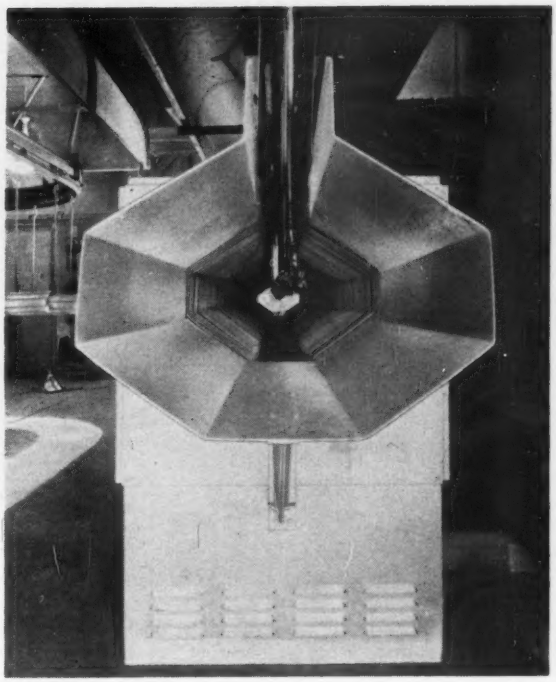
Two-tone stoving

The current trend of two-tone car body finishes raises problems in stoving owing to the need to avoid discoloration of the lighter tone on the upper half of the body. When the Ford Zodiac car was introduced this difficulty was experienced by the builders, Briggs Motor Bodies Ltd., Dagenham. All Ford bodies are finished with a durable synthetic enamel requiring a relatively high stoving temperature of the order of 300 deg F and with conventional convection stoving it was found that the already stoved upper half was reheated and became discoloured. The problem was jointly investigated by Briggs and Metrovick engineers; a decision was made to use localized radiant heating, and a pilot plant was constructed at Trafford Park. The tests proved satisfactory and a production plant was installed at Dagenham. L-shaped in plan, the plant comprises a spray booth, flash-off section, stoving section, and 6 ft vestibules at each end. Metrovick infra-red elements are fitted in 120 ft of the total length of 200 ft.

Stoving time for each body is 15 min. The original total installed electrical load of the oven, for stoving the lower half of the body, was 664 kW, which was adjustable by means of energy regulators to a normal operating load of 400 kW. Recently the use of the oven has been extended by the addition of overhead projectors to enable the upper half of the body to be stoved. The conveyor is interlocked with the banks of emitters so that should the conveyor stop the radiant heat is automatically switched off.

Component stoving

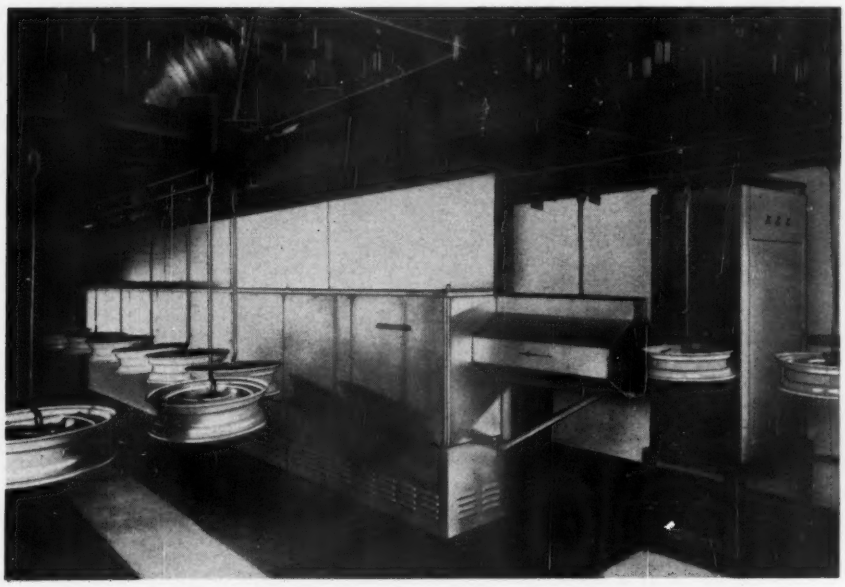
The sheathed infra-red elements are particularly adaptable as, apart from the standardized units which can be built up horizontally, vertically, or at angles to suit requirements,



End view of the Austin wheel oven, showing the specially profiled infra-red elements

they can be formed in special shapes to follow generally the profile of components and ensure rapid and even heating in production plants. An example occurs in a plant recently installed by the Austin Motor Co. Ltd., at the Longbridge Works, for stoving motor car wheels of three sizes. This replaces a previous infra-red lamp oven and was constructed to fit in with the existing monorail conveyor and the existing electrostatic spray-painting plant.

The lamp oven had a heated length of 40 ft but the new oven has only 24 ft heated and has a loading 78 kW less than that of the old one. Further economy is realized by the incorporation of energy regulators and the plant is currently



General view of the infra-red element oven for stoving road wheels at the Austin works at Longbridge. This replaces an earlier infra-red lamp oven

Static oven with bent infra-red elements for car and van bodies at works of Booth, Poole & Co. Ltd., in Eire. Dimensions are 19 ft 6 in × 10 ft 6 in × 7 ft 2 in high

taking only 75 per cent of full power. Originally the conveyor speed was 8 ft/min, giving an output of 240 wheels per hour but with the new oven it was possible to increase the conveyor speed by 25 per cent and attain an output of 300 wheels per hour. Actual stoving time was reduced from approximately 5 min to 2¾ min.

The installation provides a good example of the economies that can be effected in production time, production cost, and floor space by the use of an infra-red element plant. It is estimated that by the reduction in power charges and the elimination of lamp replacement charges a saving of at least £50 per week has been achieved.

Static ovens

The advantage of infra-red drying is applicable not only to conveyorized plants for high rates of output but also to more modest plants for jobbing or batch work. An infra-red plant has recently been installed for Booth, Poole and Co. Ltd. in Eire for drying cellulose spray-painted car and van bodies imported from Britain. The oven, 19 ft 6 in long, 10 ft 6 in wide and 7 ft 2 in wide, is constructed on an angle-iron frame which is sheeted externally to form a continuous skin and is heat-insulated on the inside. An inner framing carries the anodized aluminium reflectors, forming a continuous inner skin. On the sides and lower wings of the reflectors are mounted eighty special bent U-shaped elements, having a total loading of 140 kW.

As the ends of the elements pass through the reflectors into the cavity between the reflectors and the insulated outer skin, this space must be ventilated to comply with safety requirements. Air is withdrawn from the oven by way of a duct extending centrally along the full length of the structure. This air, containing a percentage of solvent fumes, passes through the exhauster fan and is divided, part being discharged to atmosphere and the remainder passed through a washable nylon filter to the recirculating fan. The made-up air is delivered down the back of the reflectors and enters the drying area through the bottom grille to form a slow-moving air curtain inside the oven.

A new car body goes through the following sequence of operations. In its unpainted state it is washed, blown-down, and moved into the oven to dry. Next it is taken to the spray booth where either two or three undercoatings are applied wet-on-wet. After 20 min stoving at approximately full oven loading it is then rubbed-down and dried; in the oven if it should be available. When the colour coat has been applied it is dried in the oven in 10 min at a greatly reduced loading. The gloss coat, the final application, is dried at the same oven loading in 5 min.

Complete control of the heat, both as regards intensity and distribution is effected by means of energy regulators and contactors carrying the current to four main groupings of elements. The temperature control gear, main switch fuse, fan motor starters, push buttons and fuses are all housed in a control cubicle attached to the end of the oven remote from the spray booth. Since the location is more than the regulation 20 ft from the spray booth the control gear need not be of the flame-proof type. Interlocks are arranged so that it is not possible to switch on the heating elements unless the fans are running.

BOOKS for AUTOMOBILE ENGINEERS

AUTOMOBILE CHASSIS DESIGN
By R. Dean-Averns. 2nd Ed. 30s. net. By post 31s. 0d.

AUTOMOBILE EFFICIENCY
Maintaining Performance with Electrical Test Equipment. By E. T. Lawson Helme, A.M.A.E.T., A.M.I.M.I. 10s 6d. net. By post 11s. 1d.

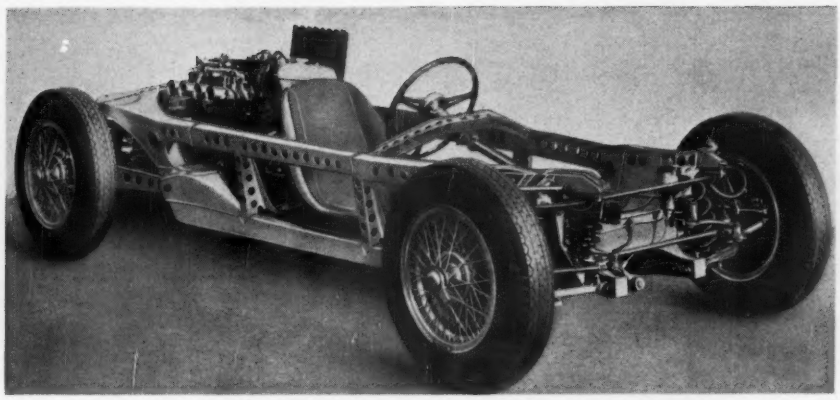
AUTOMOBILE ELECTRICAL EQUIPMENT
By A. P. Young, O.B.E., M.I.E.E., M.I.Mech.E. and L. Griffiths, M.I.Mech.E., A.M.I.E.E. 5th Ed. 25s. net. By post 26s. 3d.

GAS TURBINES AND JET PROPULSION
By G. Geoffrey Smith, M.B.E., Revised by F. C. Sheffield. 6th Ed. 35s. net. By post 36s. 6d.

THE MODERN DIESEL
Automotive Oil Engines for Transport, Marine and Industrial Use. By Donald H. Smith, M.I.Mech.E. 12th Ed. 12s. 6d. net. By post 13s. 6d.

THE MOTOR VEHICLE
By K. Newton, M.C., B.Sc., A.C.G.I., A.M.Inst.C.E., M.E.Mech.E., and W. Steeds, O.B.E., B.Sc., A.C.G.I., M.I.Mech.E. 5th Ed. 42s. net. By post 43s. 6d.

Obtainable at all booksellers or from
ILIFFE & SONS LTD
DORSET HOUSE, STAMFORD ST., LONDON, S.E.1



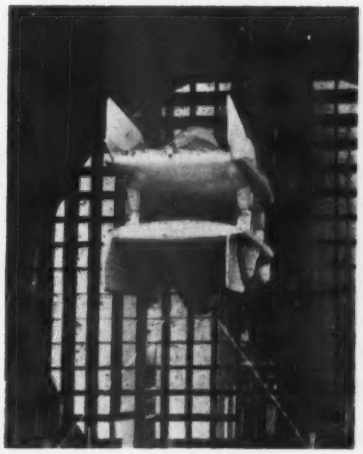
The Alfa Romeo Abarth chassis has a space-frame of fabricated rectangular sections. Its front suspension is that of the Alfa Romeo Guilietta Sprint, and the rear suspension is similar to that of the Fiat 600 model

ABARTH RECORD-BREAKING CARS

Two Vehicles Based on Fiat and Alfa Romeo Chassis with Bodies Designed and Styled by Pinin Farina

AN unusual task recently undertaken by Pinin Farina is the design of two single-seater car bodies for record-breaking attempts on the Monza track. This work has been done in collaboration with Abarth & C. One of the cars is based on Fiat 600 chassis components, the engine being bored out to give a 750 cm³ swept volume; the other is based on Alfa Romeo chassis components, and either a 1,100 cm³ or 1,500 cm³ engine can be installed. Both vehicles have a space frame. Rectangular sections, fabricated from 0·8 mm and 1·0 mm thick sheet, are used in the construction of these frames, sketches of which are shown in accompanying illustrations.

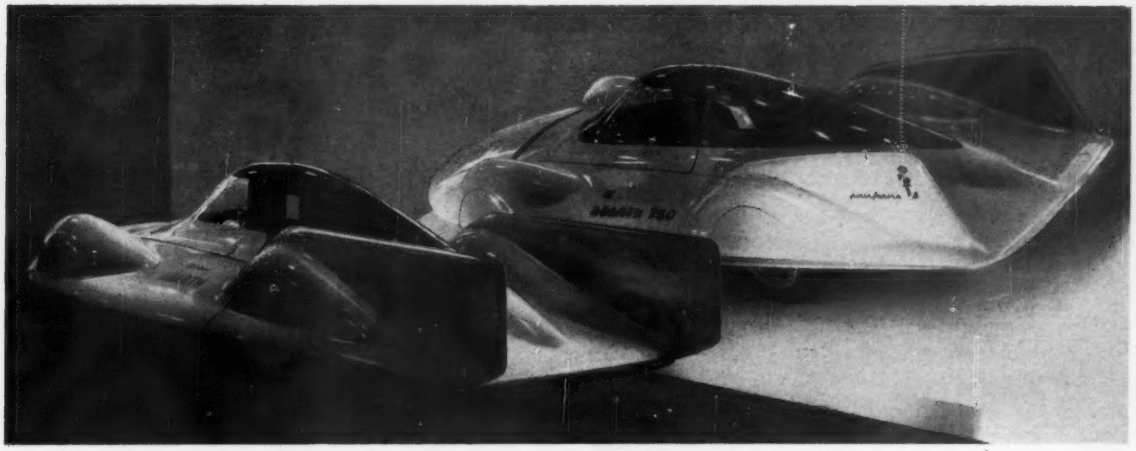
Right: For the aerodynamic tests, the models were placed in the mirror-image arrangement in the wind tunnel. Results obtained with this arrangement correlate reasonably well with those experienced with the full-scale cars on the road



Below: The rear ends of the Fiat Abarth 750 and the Alfa Romeo Abarth. Larger fins are employed on the Alfa Romeo model because of its greater weight, power and maximum speed

Fiat Abarth 750

In this car, the engine is behind the driver, but in front of the rear suspension. In other words, the engine installation is back-to-front by comparison with that of the standard Fiat 600 family saloon car. The reason for the adoption of this layout is to obtain the optimum weight distribution



between the front and the rear wheels. Another unconventional feature of the design is that the heavy components are offset to the right-hand side of the longitudinal axis of the chassis. In addition, the 73 litre petrol tank is mounted to the right of the driver's seat. This arrangement has been adopted because the vehicle is designed solely for record-breaking attempts on the banked curves of a closed circuit, the weight distribution thus obtained giving stability on the bends. The wheel reactions on the right-hand side are greater by 132 lb than those on the left-hand side.

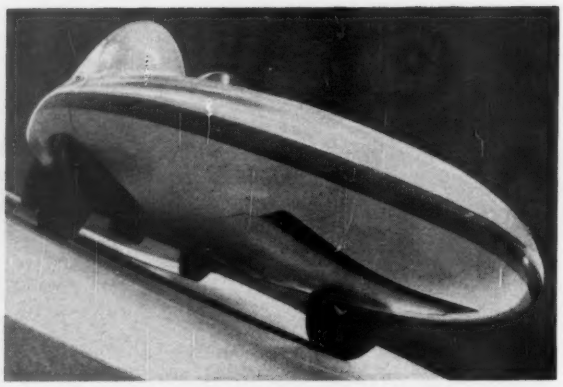
To give a swept volume of 747 cm³, by comparison with 600 cm³ of the standard version, the four-cylinder engine has been bored out to 61 mm, while its stroke remains at 64 mm. With a compression ratio of 9:1. this engine develops 43 b.h.p. at 5,900 r.p.m., whereas the standard version develops 21·2 b.h.p. at 4,600 r.p.m. Marelli 240 plugs are employed, and the carburettor is a Weber 32 DRNP2 model. An interesting feature of the cooling system is that the radiator is in front of the driver. This arrangement has been adopted to improve weight distribution. It is also advantageous because the provision of ducts for the cooling air does not interefere with the streamlining of the vehicle. The air intake is a slot in a high-pressure area under the nose of the vehicle, and the outlet is another slot, in a low-pressure area, a foot or more in front of the windscreen.

A single-disc dry plate clutch is interposed in the usual manner between the engine and the gearbox. Although the Fiat gearbox is employed, it is equipped with only the four forward gears, that is, there is no reverse speed. The differential assembly is similar to that employed on the Fiat 600. An unusual feature of the vehicle is that it has only front wheel brakes, which are hydraulically-actuated. Fiat 1100 front suspension units are employed, while the rear suspension is that of the Fiat 600 car. A worm and sector steering gear is incorporated. Wire spoke wheels with 4·5 × 15 rims are fitted, and the tyres are 5.00–15. The manufacturers state that despite the fact that the engine develops only 43 b.h.p., they expect to attain a speed of about 125 m.p.h. with the car.

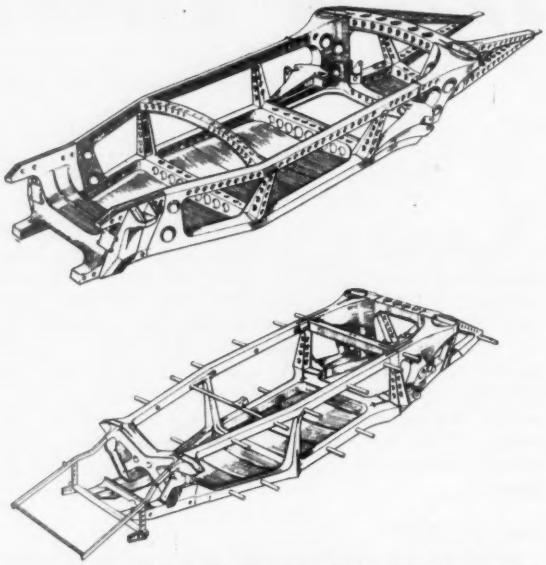
So far as overall dimensions are concerned, the following are quoted by the manufacturers: length 5,110 mm, width 1,615 mm, and height 1,100 mm. A wheelbase of 2,280 mm has been adopted, while the front track is 1,140 mm and that at the rear is 1,154 mm. The kerb weight is said to be about 1,120 lb.

Alfa Romeo Abarth

In general, the layout of this chassis is similar to that of the Fiat Abarth 750. However, because of the higher speed of the vehicle, its track and wheelbase are different. The engine, again, is behind the driver but forward of the wheels;

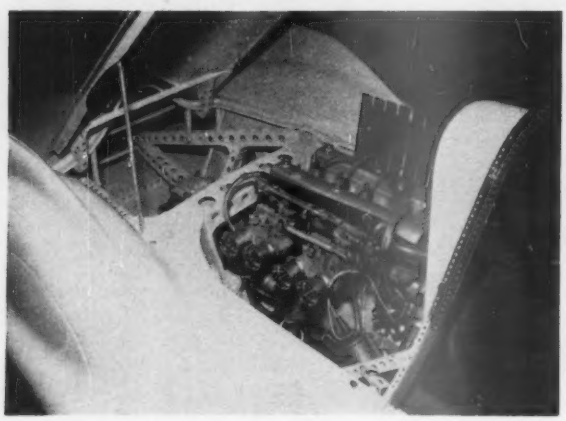


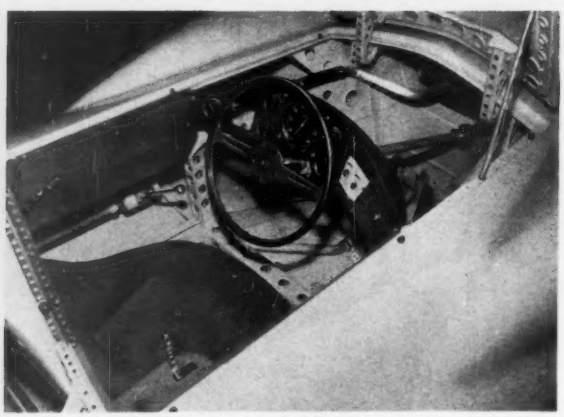
A view of the underside of the Fiat Abarth car, showing the radiator air intake slot at the front and the engine sump projecting a few inches below the under-panelling, towards the rear of the vehicle

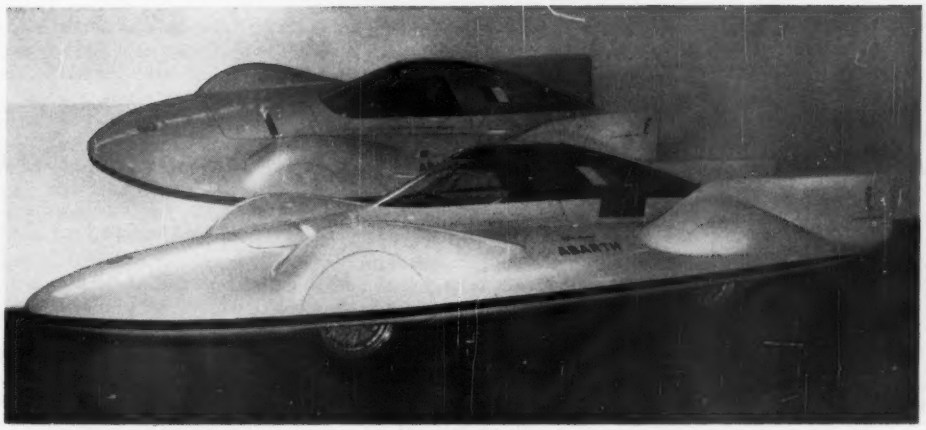


Above: Two sketches showing the arrangement of the space-frames of the vehicles. The upper one is that of the Alfa Romeo Abarth, while the lower one is the structure on which the Fiat Abarth 750 is based

Two views of the Alfa Romeo Abarth model; one shows the engine installation, with its vertical exhaust pipes, and the other is a view of the cockpit arrangement and also the control and instrument layout







Immediately in front of the windscreens of the Fiat and Alfa Romeo Abarth models, a detachable panel is fitted to give access to the radiator. The air outlet from the radiator is formed by a slot in the panel

this gives a weight distribution of 49 per cent on the front wheels and 51 per cent on the rear. Again, the distribution of the components relative to the centreline of the chassis is asymmetrical, the right-hand wheels carrying about 176 lb more than those on the left-hand side.

As has already been mentioned, this chassis can be powered by either of two engines. The 1,100 cm³ unit has a bore and stroke of 68 mm and 73 mm respectively. With a compression ratio of 8·8:1, the maximum power output is 73 b.h.p. at 6,800 r.p.m. The 1,500 cm³ unit has a bore and stroke of 79 mm and 75 mm respectively. Its compression ratio is 9:1, and it develops 105 b.h.p. at 6,800 r.p.m. Marelli 260 plugs are employed. Carburation is effected by two Weber, twin-choke type 40 DCO3 units. As on the Fiat, the radiator is at the front.

A single-dry-plate clutch transmits the drive to the four-speed gearbox, which, as in the previously described model, does not have a reverse speed. The differential assembly is housed in the gearbox, and the layout of both the transmission and the rear suspension is similar to that of the Fiat 600. At the front, the suspension is that of the Alfa Romeo Guilietta Sprint. A cam and roller type steering gear is employed. The wire spoke wheels have 4·5 × 15 rims and 5.25–15 tyres. Front wheel brakes only are fitted and they are hydraulically-actuated.

An overall length of 5,680 mm is quoted. The width is 1,690 mm and the height is 1,100 mm. A wheelbase of 2,410 mm has been adopted, while the track is 1,220 mm at the front and 1,178 mm at the rear. This vehicle, like the Fiat Abarth, has a ground clearance of 150 mm. A kerb weight of about 1,365 lb, with the 80 litre petrol tank full, is quoted. It is expected that this vehicle will reach a speed of approximately 187 m.p.h.

Bodywork

The bodies of the two cars are so much alike that at first sight it is difficult to distinguish between them. In fact, the two main differences are as follows: the model powered by the Alfa Romeo engine has a row of eight exhaust pipes protruding almost vertically on one side of the fairing behind the cockpit hood and, because of its relatively high speed, it has larger tail fins than the Fiat version. On both models, the windscreen is integral with the cockpit hood and the assembly is hinged at its leading edge. so that it can be lifted to give access to the driver's seat. The fairing behind the hood is hinged at its trailing edge so that it can be raised to give access to the engine and transmission.

One aim in the design of these bodies has been at minimizing air-drag by keeping the frontal area as small as possible. This has been done mainly by making the body as low as practicable. The fact that the cockpit hood is small and well streamlined also helps a great deal. It was not possible to reduce the overall width, which was determined by the track dimensions needed for stability. The wheels are completely faired by the body panelling, as also is the whole of the under-surface of the chassis. In the Fiat model, the engine sump projects below the fairing, but the sump of the Alfa Romeo engine does not project.

As can be seen from accompanying illustrations, the bodies are of relatively flat form, so that the effect of side winds is minimized. The fins of the two versions are similar in form, but those on the Alfa Romeo are extended further to the rear than those on the Fiat model.

Aerodynamic tests were made on one-fifth scale wooden models of the cars, in the wind tunnel of the Polytechnic of Turin. As can be seen in an accompanying illustration, the models were placed in the tunnel, one above the other, with their wheels in contact. This arrangement was found to be most convenient, because it obviates the difficulty of representing a road surface beneath the models. The introduction of a plane to represent the road interferes so much with the air flow in the tunnel that grossly misleading results are obtained, whereas the method adopted was found to give results that correlate reasonably well with those obtained from tests with full-scale cars on the road and on the track.

Suspension Development

THE latest research technique employed by the German automobile industry makes use of an analogue computer to simulate the effect of road conditions on projected vehicle suspension systems. It is said that the adoption of this new technique has made it possible to determine, in as short a period as one hour, the type of suspension system best suited to the needs of new lorries and heavy haulage vehicles. A British made Short analogue computer is used.

The method adopted is to set up on the computer an equation in which such factors as the type of axle to be used, the suspension and chassis, and various types of bumps and road depressions are represented by electrical voltages of varying values. When the simulated suspension system is "driven" over the bumps, a trace on the cathode ray tube of the computer indicates the actual movements of the chassis and axle arrangements. By merely turning appropriate switches, it is possible to change such values as the stiffness of the suspension springs, pressure in the tyres or damping of the shock absorbers, until a system is evolved that gives the best performance. Work that previously took weeks of research can be completed in an hour at the computer.

Testing Friction Materials

A Discussion of Development Practice in the Laboratory and on the Road

N. Carpenter,* B.Sc., Ph.D., A.M.I.Mech.E.

In post war years, a number of features have led to an increase in the demands made on brake linings. In the automobile field the trend towards smaller wheels, in the interests of reduced unsprung weight, has of course caused brake sizes to be reduced, whilst the currently popular streamlined body styling tends to deflect the cooling air currents away from the brakes. In general, the performance of cars has increased enormously in a relatively short period of time; concurrent with this increase, standards for brake performance that are higher than ever before are being set. Owing to the high density of traffic on roads in many parts of the world, it is becoming increasingly important that a vehicle should be well braked, and it may be said that under these conditions efficient braking contributes almost as much to speed in motoring as does the acceleration of the vehicle. It is scarcely surprising, in view of what has been said above, that an increasing number of firms in the automotive industry are conducting brake tests in some form or another, and that a number of different views are held regarding the form to be taken by these tests. It is therefore felt that an outline of the testing procedure adopted in the development of brake linings, which is based upon an accumulation of experience as old as the automobile industry, might be of value.

For a variety of reasons it is not always practicable or desirable to conduct the tests on a complete vehicle on the road; therefore a number of different forms of test machines are used to examine certain particular features of the friction linings. Brake lining manufacturers are constantly improving their products and in the course of this development work may produce dozens of experimental linings in a single week. In these circumstances it is obviously not practicable to test all these linings on the road and the test machines are used virtually as a filter to reject any experimental lining that does not show considerable promise, before the successful few pass forward for road testing.

Behaviour of Friction Materials

The testing of friction materials is greatly complicated by the obscure nature of the friction phenomenon. This is normally dismissed lightly by the use of an appropriate constant, called the friction coefficient, but with most of the commonly used materials this coefficient does not in fact remain constant under all conditions. The friction coefficient can be affected to a greater or lesser degree by the temperature of the material, by the pressure and by rubbing speed at the contacting surfaces. It is also susceptible to change owing to contamination by, for example, oil or by water either from humid atmospheres or from immersion if the vehicle is driven through floods or water splashes. In addition, the friction material is temporarily affected by the heat generated in the friction process and, since this influences only the surface layers, the material can develop an apparent history consciousness. In other words, the behaviour of the material under a given duty can be influenced to some extent by the treatment which it has previously received. Time effects can also enter into the measurements. In certain types of test machines prolonged rubbing at a fixed speed, temperature and pressure is used. This can cause a conditioning of the surface of the material so that, within the duration of the brake application, its behaviour may change, owing to the build up of extremely thin resin films on the drum surface. These effects do not generally show themselves in vehicle operation; but they must be considered in assessing the results from test machines, because of the artificial conditions of machine testing.

A further difficulty that arises in testing friction materials is that the various demands put upon brake linings have led to the development of material whose nature is such that an overload test cannot be used to determine the general behaviour. A material that shows the best performance under overload or very severe conditions may not necessarily be the best in normal operation.

Bearing these features in mind, it is most important that the friction materials should be tested under conditions closely simulating those it will encounter in service. As soon as consideration is given to motor vehicle brakes and clutches, however, it becomes evident that little data is available on the actual operating conditions of the friction materials.[1] A certain amount of information has been compiled on deceleration rates, etc., imposed upon vehicles under test conditions; some information on these lines refers to conditions of normal duty[2] but, as yet, the share of the load taken by the brake linings in normal duty by comparison with that absorbed by various drag forces on the car, has had little attention. We require, therefore, to simulate conditions about which little information is available. In fact, the test conditions in use have largely been developed over a period of many years from a very careful consideration of practical conditions, coupled with frequent and regular comparisons between the results obtained on the test machines and test cars on the one hand and results obtained in general service on the other. Only when good correlation occurs between such results can real confidence be felt that the conditions being used on the machine or test car are truly representative of the general service on the vehicle.

It stands to reason that the test conditions must be varied according to the ultimate use to which the lining is to be put. For example, in developing a lining for racing purposes, it is important that high rubbing speeds be used; similarly the duties to be simulated for private cars, trucks, buses, aircraft and industrial applications generally differ considerably from each other. Adaptability is therefore a prime requirement in any machine to be used for friction testing. Moreover, skilful use of this adaptability must be made, after careful examination of the conditions to be simulated, so that the required temperatures, stopping times, torques, rubbing speeds, etc., can be duly reproduced.

In view of these difficulties it might be suggested that vehicle testing should replace machine testing, so that the test conditions would always be related to practice. Unfortu-

*Technical Sales Manager, Ferodo Ltd., Chapel-en-le-Frith.

nately it is difficult to make precise and controlled experiments on a normal vehicle not designed for the purpose; furthermore, the use of a road vehicle for brake lining tests is very tedious and expensive owing to the very large mileages that must be covered to ensure that adequate wear resistance and good behaviour can be obtained throughout the life of the lining. Any attempt to accelerate road testing, by extra brake applications, is extremely risky and should be treated with very great care. This is because it is not possible to increase the rate of cooling to compensate for the higher rate of working, as can be done on the test machines. Therefore, although the test is conducted on a vehicle, the conditions in fact may not be representative of service conditions. The principal exception to this is when Alpine or mountain motoring is simulated in relatively flat country. In this instance, it is obviously necessary, for test purposes, to make extra brake applications, but this should only be done with a full knowledge of the conditions that prevail in the mountainous countries.

In comparison with road testing, machine testing speeds development by eliminating a number of time-wasting factors. Cooling can be accelerated by the use of fans so that an increased number of brake applications can be made in a given time without over-heating the brakes; also, by the use of automatic controls, the brakes can be worked day and night without the need for a large team of drivers.

Testing procedure adopted in the development of a new brake lining or clutch facing can conveniently be divided into three stages: the first is a series of tests on laboratory scale equipment, the second comprises full size dynamometer tests, while the third and final stage is the tests conducted on a range of vehicles. Since these final tests show the suitability of the new lining for only certain vehicles, this stage should be extended by field tests intended to explore the boundaries of the field of application of the lining and to confirm in general service the findings made under test conditions.

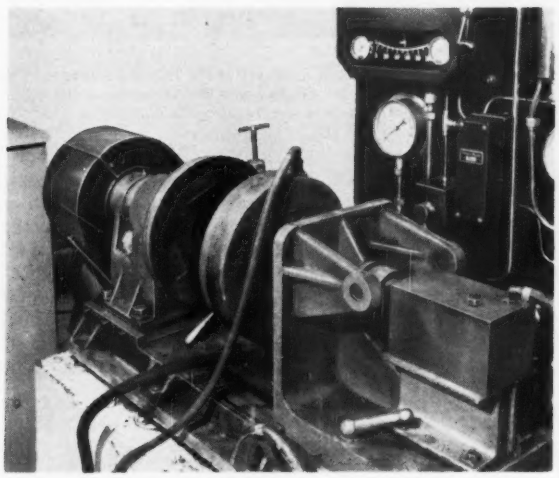


Fig. 1, above: A friction test machine with a constant speed drive, suitable for quality control using small samples. This machine is not recommended for general assessment of materials for automotive duties

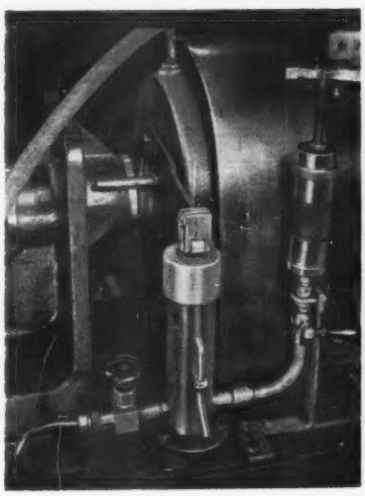


Fig. 2, right: The rear view of the machine illustrated above, showing the torque arm and hydraulic cylinder

Laboratory scale test machines

Laboratory scale test machines are used for a wide variety of purposes in the brake lining industry. They consist generally of a drum or disc, driven at a uniform speed, against which a small sample of the friction material is pressed. The sample size is often of the order of 1 to 3 in², so that samples can be cut from almost any piece of friction material and adapted to the shape of the disc or drum. Because of the relatively large scale structure of the woven type of friction materials, the samples should not be too small. The brake application is of long duration, of the order of 10/100 minutes, and this type of braking is often referred to as the continuous rubbing duty. This type of test has the virtue that the wear rate of the material can be assessed relatively quickly, since no testing time is wasted, for example, in cooling the assembly. However, since it does not correspond directly with the types of duty imposed in normal service, it has obvious shortcomings.

Fig. 1 shows a typical small scale test machine. The recesses in the face plate, which carry the samples under test, can be seen clearly. This plate is driven at a uniform speed. The torque plate, which can be identified in Fig. 1 by the water-cooling pipes, is pressed against the samples. To apply this pressure, either the hydraulic ram in the right-foreground is employed, or a dead-weight lever system can be fitted on the needle-roller bearings, which can be seen near the pressure cylinder. The non-rotating part of the machine is mounted on a slide so that it can be drawn back to enable the samples to be inspected or replaced. Fig. 2 shows a view from the rear of the machine, the torque plate being in contact with the samples and the guard in position ready for the start of a test. Also to be seen in this illustration is the equipment for torque measurement. The shaft carrying the torque plate is mounted on bearings, so that it would be free to rotate if it were not restrained by a radius arm resting on the top of a piston in a hydraulic cylinder. With this arrangement, the hydraulic pressure can be observed and recorded and translated in terms of torque output. From a knowledge of the torque and the normal load on the samples, the coefficient of friction can be calculated. Wear can be assessed by weighing and measuring the samples before and after test.

Machines of this type are used in some quarters as the first filter, in the determination of experimental qualities, but the author is of the opinion that the results obtained with them can be extremely misleading except on a comparative scale. They are also used for quality control testing: a certain scatter in the wear and friction measurements is determined with early batches of the material in question, and subsequent batches are required to exhibit friction and wear values within this scatter. It is obvious that work of this nature demands the exercise of extreme care in sampling but, with this proviso, it can assist greatly in the maintenance of quality. It should, however, be stressed that owing to the unnatural working conditions on these continuous

application test machines, the absolute values obtained for friction and wear, and the effect upon them of the different variables, will be in general different from those that would hold in normal service. These machines are not, therefore, suitable for the basic assessment of a friction material in regard to its suitability for use on a motor vehicle.

Inertia test dynamometer

The inertia test machines are generally so proportioned that a complete vehicle brake can be mounted for test, Figs. 3 and 4. They consist basically of a driving motor, coupled to a shaft carrying a bank of flywheels. The brake drum is mounted on one end of the shaft while the brake back-plate and shoe assembly unit is attached to a torque reaction member mounted in line with this shaft. The torque reaction member is so designed that the torque loads imposed on it can be indicated or recorded either by means of strain gauges or by a radius arm pressing on a hydraulic piston to generate pressure, which can be registered on a Bourdon-tube type of recorder. Usually the brake reaction shaft is mounted so that it can slide back to allow the brake to be withdrawn from the drum for examination. One flywheel is keyed to the shaft and, therefore, always revolves with the brake drum. All the other flywheels are mounted on bearings on the shaft and are free to remain stationary when the shaft revolves; thus they contribute nothing to the inertia of the machine unless they are bedded to the fixed wheel. By utilizing different numbers of flywheels, the inertia of the machine can be adjusted to give approximately the required kinetic energy at the appropriate shaft speed to simulate the conditions obtained on the vehicle.

Tests are carried out in the following manner. The flywheels are accelerated by means of the driving motor until the brake drum reaches a speed corresponding to the desired road speed of the vehicle. Then, the driving motor is declutched or shut down and the brake is applied to bring the machine to a standstill. After a pre-determined dwell period the machine is again brought into operation as before. This cycle of operations is repeated many hundreds of times in a single test, the speeds and deceleration torques employed being varied.

The test generally consists of groups of perhaps 30 to 100 stops, each under some particular conditions of deceleration and speed, with cooling periods interposed between the groups. The conditions then resemble those that would be encountered by a vehicle driven in flat country, and approximate to the conditions encountered in hilly country, except in that the occasional long periods of low-torque brake application incurred on some lengthy gradients are omitted.

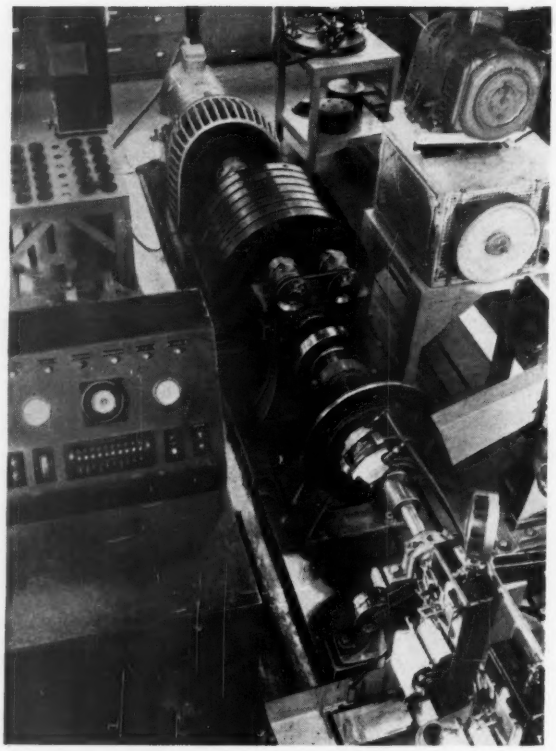
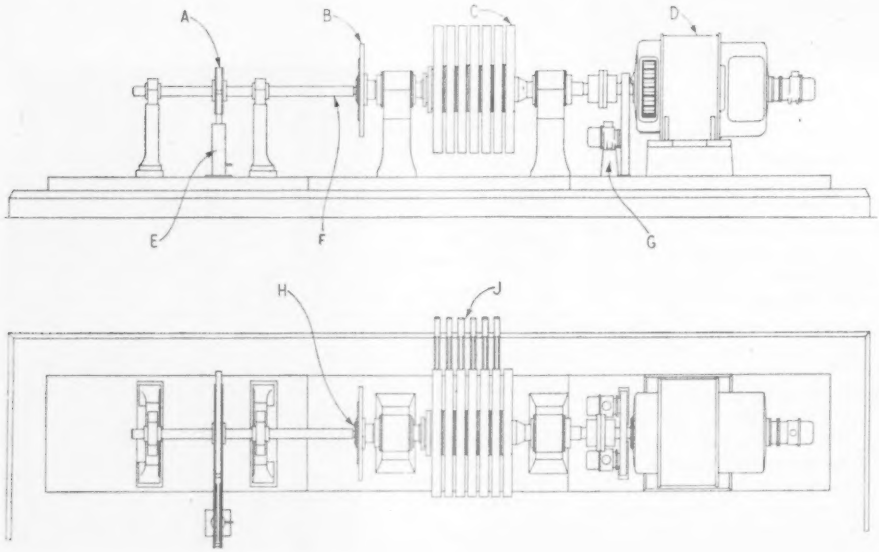


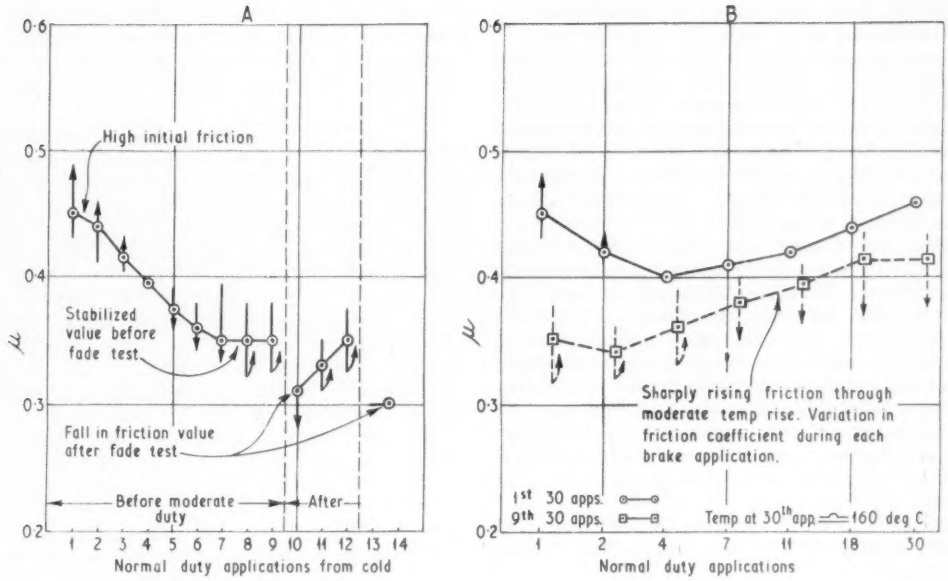
Fig. 3. One of the inertia test machines in the Ferodo test house. The torque shaft and arm and the pressure and torque recorders can all be seen in the right-hand foreground of the illustration

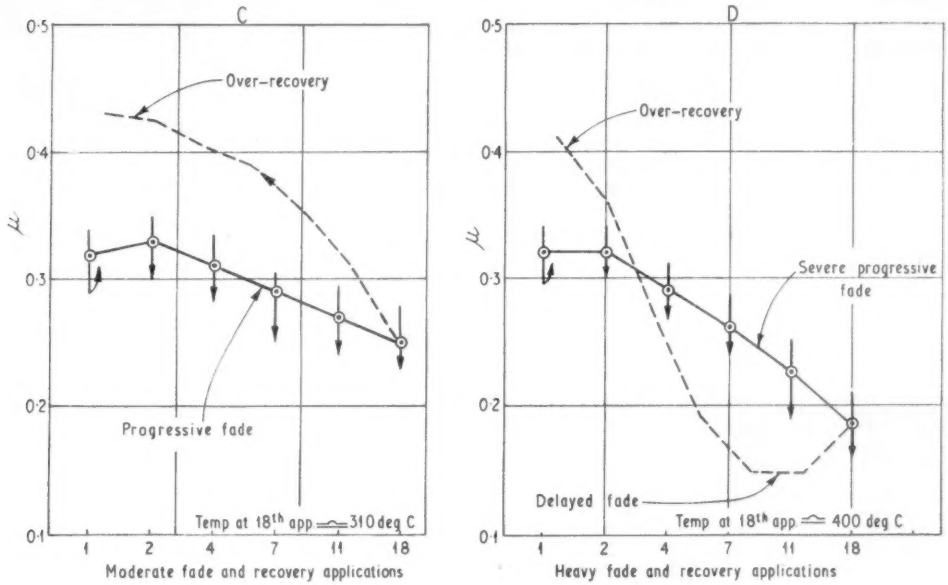
Test schedules vary enormously, according to the application of the brake or lining under test, but consideration of a typical brake lining test will serve to illustrate the general procedure. Fig. 5 shows graphically some entirely imaginary results obtained from a typical inertia machine test. The

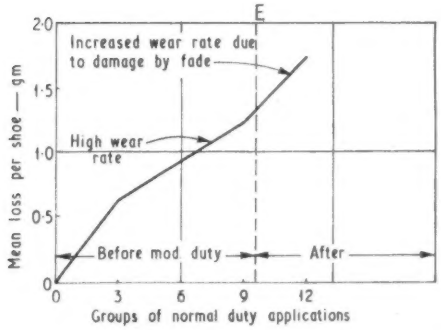


A *the torque arm;* **B** *face plate for drum mounting;* **C** *flywheel fixed to shaft;* **D** *electric motor;* **E** *cylinder for the measurement of torque in terms of hydraulic pressure;* **F** *torque shaft;* **G** *tacho-generators for speed indication and control;* **H** *bearing in face plate, to support stationary torque arm;* **J** *snagging levers for free flywheels*

Fig. 4. A typical layout for an inertia test machine


A
High initial friction
Stabilized value before fade test
Fall in friction value after fade test
Before moderate duty
After
Normal duty applications from cold
B
Sharply rising friction through moderate temp rise. Variation in friction coefficient during each brake application.
1st 30 apps.
9th 30 apps.
Temp at 30th app 160 deg C
Normal duty applications





Type of duty		Mean loss per shoe gm	Mean loss per shoe in × 10⁻³	Life b.h.p-hr/in²
Normal	Before mod. fade	0·29	1	249
	After mod. fade	0·63	2	113
Moderate fade		0·5	1	79
Heavy fade		0·92	4	43

Weight loss and specific life

F Drum heat-spotted after moderate fade test. Heavy smoke during severe fade test. Lining cracked at rivets after test

A *cold friction*; **B** *friction/temperature*; **C** *moderate fade test*; **D** *severe fade test*; **E** *weight loss*; **F** *observations*

Fig. 5. Result obtained with a typical test schedule. The shapes of the curves have been chosen to illustrate a large number of the faults that can be identified from the results of this type of test

curves have been deliberately drawn in such a form as to illustrate a large number of faults in a friction material, which can be disclosed by a test of this kind. It should also be realized that tests of this type show all variations to the full whereas they are usually minimized in general service. For this particular test the inertia of the machine is required to correspond to 30 per cent of the inertia of a 1½ litre family saloon car, that is, to the effective inertia operative on one front brake of a vehicle with 60 : 40 braking ratio. The test schedule is outlined below.

Group One. The first group consists of 30 stops each from 40 m.p.h. to a standstill, at an equivalent vehicle deceleration of 0·4g; the brake applications are made on a 30 second time cycle, that is there are 30 stops in 15 minutes. Throughout the cycle the cooling fan is operative, and the brake temperature rises progressively under the repeated stops from room temperature at the beginning to a medium operating temperature in the later stops of the group.

Groups Two to Nine. These are identical with the first group. The brake is cooled to room temperature between each group so that each stop is an exact repetition of the previous one.

Moderate Fade Test. This test consists of 18 stops from an equivalent road speed of 60 m.p.h. to a standstill, at an equivalent vehicle deceleration of 0·5g. The time cycle for this group is 40 seconds and the cooling fan is operative throughout the test. At the beginning of the test, the drum is at room temperature; subsequently the temperature rises, as a result of the increased energy dissipated, to a level that is moderately high but which the lining should be capable of withstanding without any serious damage. To observe the degree of damage done during the fade test, a number of stops are made from low speed to allow the frictional behaviour during the cooling period to be observed. The reason for using low speed applications is to cause the minimum possible interference with the cooling process. These stops are referred to as the recovery stops.

Groups Ten to Twelve. These are identical with Groups one to nine.

Fig. 6. A special test rig mounted on an inertia dynamometer for use in connection with the work for one particular investigation

Severe Fade Test. The severe fade test consists of 18 stops from the same speed and at the same deceleration as for the moderate fade test. Although the time cycle is the same, the cooling fan is shut down so that very much higher temperatures are reached.

Part A of Fig. 5 shows friction values recorded on the first (cold) stop of each of the 12 groups of normal stops. The vertical dotted lines indicate the positions at which the fade tests are interposed. This curve gives an impression of the behaviour that might be encountered at the beginning of each of a succession of journeys after fitting new linings. In each case the brake drum is initially at room temperature and the heat built up in the course of a single application is not great, so this group test result is usually referred to as the cold friction graph. A typical fault illustrated by this diagram is the high initial friction of the material during the process of bedding to the drum; this might lead to squeal or grab during the very early life of the material. Other faults are the variation of the friction coefficient during each individual brake application, and the reduced friction level after fade due to some degree of damage to the surface layers of the material. It will be noted that the work done on the material by the tests in groups ten to twelve restores its normal behaviour; this indicates that the damaged surface has been removed. The single point plotted outside the diagram, to the right, indicates the cold friction value after the second fade test, which again shows the effect of damage due to high temperatures.

Part B of Fig. 5 shows the effect of temperature upon friction throughout the progressive temperature rise that occurs over the successive stops of each group. As the temperatures reached are only moderate, the friction should be quite stable within this range, whereas the diagram has been drawn to illustrate a sharply rising friction/temperature characteristic. Such a rise is undesirable because any slight irregularity in circumstances may cause one brake on the vehicle to become a little warmer than its partner. If this occurs and the friction rises noticeably, the brake will tend to take an increased share of the work and, therefore, become even hotter. Ultimately, the brakes will tend to pull consistently to one side.

The full line shown in part B indicates the initial behaviour of the friction material during the first applications after fitting. While the dotted line indicates the characteristic obtained after the material has fully settled to its normal operating condition. Needless to say, these two curves should generally be very close together and similar in form, indicating that little change occurs during the bedding-in of the brake lining. It should, however, be emphasized that on any vehicle brake the bedding-in characteristics are to some extent dependent upon the brake geometry and not solely upon the friction material. The particular brake applications (1, 2, 4, 7, 11, 18 and 30) which have been recorded in part B have been chosen because measurements have shown them to occur at roughly equal temperature increments for this particular test machine. Therefore, the graph shows the linear relationship between friction and temperature up to a temperature of about 160 deg C, as indicated by thermocouples in the near surface of the brake drum. It should be emphasized here that temperature measurements on braking systems can be extremely misleading, owing to the considerable gradients imposed by the heat input. Not only are these gradients very steep near to the rubbing surfaces, but they are also transient. Different methods of measuring temperature can, therefore, give widely differing results for one brake working under one set of conditions. For this reason, it is imperative when referring to a brake temperature to indicate just what has been measured and how it has been measured so that the relative significance of the figures can be assessed.

A moderate fade test is shown in part C. The temperature rises to about 310 deg C, as indicated by the thermocouples bedded in the drum. Again a rising friction coefficient of the lining is shown at modest temperature, followed by progressive and relatively moderate fade. Under these conditions, however, a fade resistant lining should show little or no fade. In addition, it can be seen that the cold friction recorded on the first application of the group is appreciably lower than that shown in the groups from 40 m.p.h. This indicates a speed/friction characteristic that is obviously undesirable. In point of fact the friction level at the start of the fade test should be as near as possible to that indicated at the start of the normal groups.

During the recovery stops the lining exhibited an extremely high friction. This phenomenon is known as over-recovery and leads to erratic behaviour of the vehicle when the brakes are applied after they have had some cooling following relatively heavy duty. As the cooling is generally unequal on the four wheels, it would be quite possible, on the evidence of the test result shown in Fig. 5, to have one brake operating at a friction coefficient of 0·25, whilst another has reached 0·41. Under such conditions, it would be extremely difficult to keep the vehicle on the road. Severe over-recovery is, therefore, a serious fault. In considering the amount of over-recovery exhibited by a lining, care should be taken to compare the friction level during the recovery stops with the friction level during the low speed performance groups, instead of with that at the beginning of the fade test. This is important because the recovery stops are normally made from the lowest speed used for normal performance tests, that is, 30 to 40 m.p.h., and a speed effect can be mistaken for over-recovery.

The severe fade test shown in part D illustrates a considerable and progressive fade. This could perhaps be of greater danger if the onset of fade were more sudden but, nevertheless, the fading during the stop and the overall degree of fade as shown on this test would be excessive.

As the brakes cool, the friction falls to an even lower value. This phenomenon is known as delayed fade. It can be extremely dangerous in service, as, when a vehicle is being driven hard, fade normally causes the pedal to become progressively heavier, but the driver conditions himself to the heavier pedal and drives appropriately. However, if after the drums have had an opportunity to cool he is called upon to make an emergency application, he will anticipate the normal cold behaviour of the linings and if delayed fade has occurred he can find himself virtually without brakes. Delayed fade, therefore, is an extremely dangerous feature, which cannot be tolerated in any brake lining for general service. It may be associated with a more or less complete lack of recovery on the part of the lining or it may, as shown in the diagram, be associated finally with over-recovery or normal-recovery to the pre-fade level of friction.

The wear of the brake lining can be assessed either on the basis of the weight loss or by the reduction in thickness, during the course of the test, as measured by means of a micrometer. It is generally desirable to measure both these values because the actual amount of material removed is very small and one method of measurement serves as a check on the accuracy of the other. Further, unless precautions are taken, a small amount of moisture may be absorbed while the brake is stationary; this moisture may be driven off during the braking, and a misleading value for the weight loss might be obtained since the actual weight of material worn away in each individual part of the test is so very small.

Although the illustration just discussed by no means exhausts the possibilities of inertia machine testing of friction materials, it should suffice to give a picture of a typical procedure. Special equipment is required to study squeal, judder and related phenomena on a test machine, because the characteristics of the suspension system of the vehicle may well be involved. Fig. 6 shows a test machine rigged for an investigation on brake judder. For this purpose the front portion of the chassis of a vehicle was mounted over the test machine so that the road wheel was pressed against a drum mounted on the face plate of the machine. In this way the phenomenon could be studied with the brake mounted in the correct manner.

The graph shown in part E indicates the trend of weight loss under normal duty during the course of the test. Initially, a high rate of wear occurs, owing to the removal of high spots from the surface of the lining. This then steadies down to a more normal figure before the medium fade test. After this we have postulated for our imaginary brake lining a degree of semi-permanent surface damage, which would lead to an increased wear rate. With a satisfactory brake lining there should be no increase. The table of wear values shows loss of weight and thickness over the various portions of the test and, from a knowledge of the amount of energy dissipated, life values in terms of the amount of work required to destroy one cubic inch of material have been determined. It will be observed that the life values vary considerably according to the temperature and general conditions of operation. For this reason, the life values of friction materials are not generally quoted: the wear rate depends not merely upon the amount of work done upon the lining but also is considerably influenced by the conditions, in particular the temperature, under which work is effected.

Tests conducted on the complete vehicle

Performance Tests. This is the title normally given to the tests conducted to observe the relationship between the load exerted by the driver on the brake pedal and the resulting deceleration. These tests must be conducted on a level stretch of road, a series of stops being made from a fixed initial speed at suitable increments of pedal load. Pedal load may be observed either directly on a pressometer, or indirectly by means of a pressure gauge connected into the brake pipe-line. The latter method is to be preferred for regular brake testing because it reduces the chances of errors due to the foot imposing non-axial loads on the brake pedal. As only the normal component is effective, the assessment of such loads can be misleading because the side loads can introduce friction forces in the mechanism so that a portion of the observed force is ineffective. In the installation of pipe-line pressure gauges great care is required to avoid trapping air in the system. The Bourdon tube of the gauge should be filled with brake fluid either prior to its being fitted to the vehicle or, preferably, by utilizing a gauge fitted with a bleed screw on the Bourdon tube and bleeding the system at this point.

A variety of decelerometers are available and any continuously indicating instrument can be used. The Tapley decelerometer [4, 5], since it has an open scale, is ideally suited to this type of work and should be used in the "free" condition, that is, not with the ratchet set to trap the mechanism at the maximum deceleration position. The decelerometer would normally be read by an observer riding in the vehicle, but alternatively a recording decelerometer could be used. Any definite changes in the deceleration caused by the constant pedal effort should be noted but care should be taken not to be misled by transient peaks or dips caused by roughness of the road surface or other external factors.

For a heavy vehicle these performance tests would normally be made by braking from 20 m.p.h. to a standstill, out of gear or with the clutch depressed. For cars it is customary to make two tests, one from an initial speed of 30 m.p.h. and one from 50 m.p.h. as shown in Fig. 7 A and B.

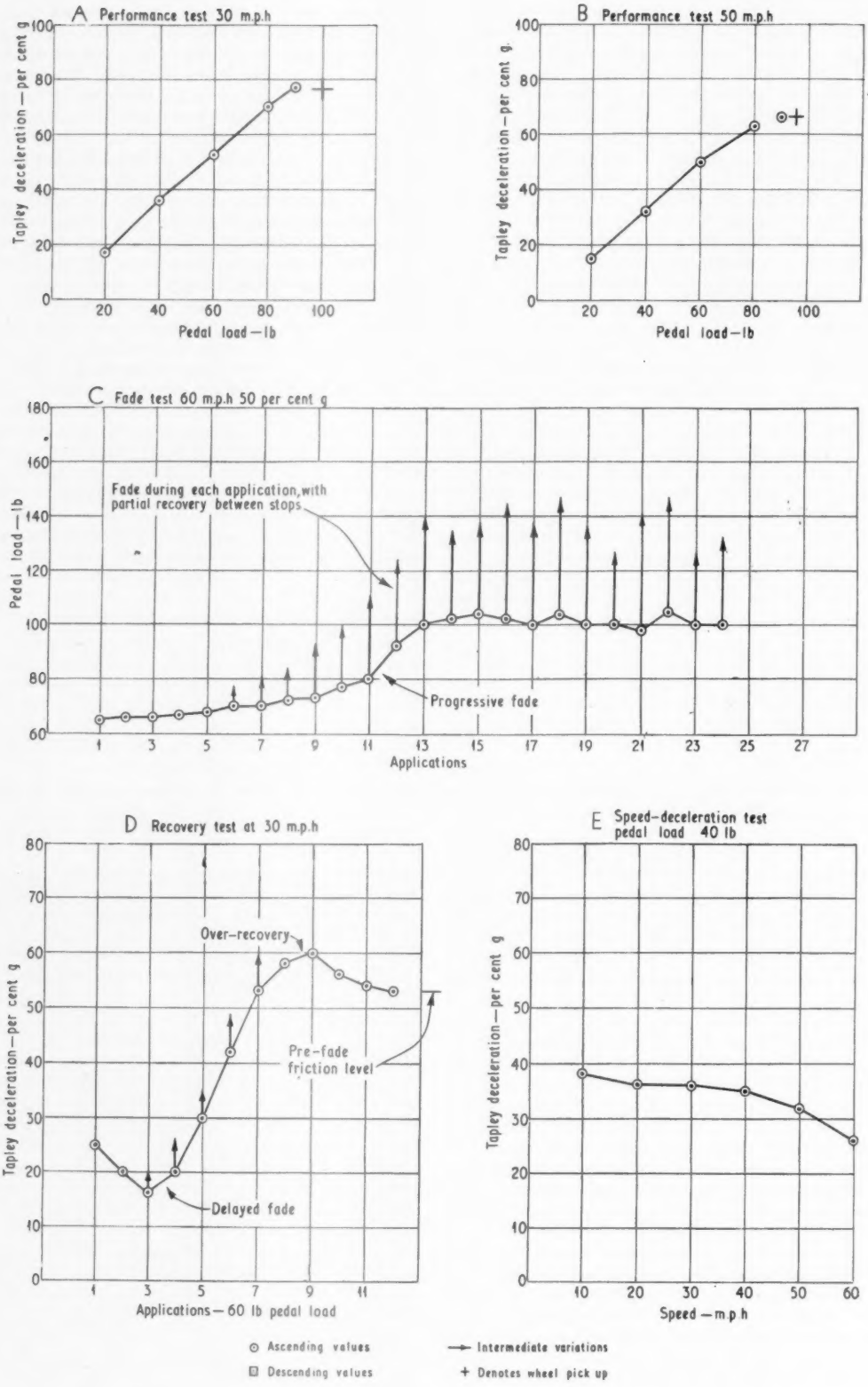


Fig. 7. Typical results obtained from a vehicle test. The fade test illustrated is extremely severe but shows that even this overload can be sustained by a modern braking system

Any difference between the two curves serves as an indication of the effect of vehicle speed upon the braking efficiency. Throughout the tests the brakes must be given adequate time for cooling between the brake applications, so that the temperatures to which the linings are subjected are kept moderately low.

This performance test would normally be repeated at various stages in the life of the lining, so as to determine its initial performance immediately on fitting to the vehicle, its performance when run in and well bedded to the shape of the drum, its performance after an appreciable mileage, to show whether there is any improvement or deterioration, and again after any fade test or severe duty, so that any damage arising from the high temperatures can be observed.

Speed/Friction Test. Again, a level stretch of road is required; the vehicle is accelerated to a relatively low speed, the brakes are applied at a pre-determined pedal effort, with the gear disengaged, and the deceleration noted. This test is then repeated from progressively increasing speeds to produce the type of result shown in Fig. 7E. In general, some deterioration in performance with speed occurs, but it is obviously desirable that this should be kept to a minimum. The stops should be made from speeds rising to near the maximum speed of the vehicle; throughout these tests the brakes should be kept relatively cool.

Fade Test and Recovery Test. The fade test is usually designed to raise the temperature of the brake drum very rapidly to an elevated temperature and to observe the behaviour of the brakes throughout this process; temperatures should equal or exceed the maximum which will ever be reached in service and this test does, when properly conducted, place very severe demands upon the whole vehicle. For private cars, the test is normally conducted on a level stretch of road, preferably on private roads such as the M.I.R.A. proving ground. It is advantageous if these roads form a closed circuit, because little time is available for slow speed manoeuvres, such as turning, once the test has commenced. Alternatively, if reasonable room is available to swing the vehicle round at each end of a straight track, a fade test can be conducted by making stops in each direction.

For the fade test the vehicle is accelerated to a relatively high speed, generally of the order of 80 per cent of the maximum speed of the vehicle; it is then braked to a standstill or to a pre-determined low speed, at a pre-determined deceleration as observed from a decelerometer carried in the vehicle. The pedal effort required to produce this deceleration is noted by an observer, and the whole process is repeated on a time cycle with very little time between successive applications. A U-tube type of decelerometer fitted to the windscreen forms the best guide to the driver in maintaining a fixed deceleration, since its scale comes directly in his line of vision. A graph of an extremely severe fade test, in which the initial speed was 60 miles an hour, is shown in Fig. 7C. A deceleration of 0·5g and a cycle time of 27 seconds was maintained for 24 stops.

During the process of this test, the brake pedal will generally become heavier. It is always possible that experimental linings might show some erratic behaviour that could be dangerous if the vehicle were used in this manner on the public roads. It is, of course, virtually impossible, in conditions of general traffic, to ensure that there will be no interruption in the operation of the required cycle. If the cycle is interrupted, direct comparisons cannot be made between one test and another, because at the elevated temperatures reached in the test, cooling is rapid and therefore cooling time has to be carefully controlled. These are the main reasons why the test should not be made on public roads.

The purpose of conducting the test at a constant deceleration rather than at a constant pedal effort, which might be easier to control, is to ensure the maintenance of the appropriate time cycle; since otherwise the stopping time could increase if the lining faded. It is also necessary that the rate of working at the brakes should be maintained constant so that the temperature gradients built up in the brake drum should be the same whatever the behaviour of the lining under test. This can only be ensured by the use of a fixed braking torque or deceleration. A further point that should be noted is that the load carried by the vehicle has a considerable effect on the relative severity of the fade test. The vehicle can be tested either in a normal state of loading or when carrying its maximum load but the two results cannot be directly compared.

After the fade test, it is customary to determine the "recovery" of the lining. In order to do this, it is necessary to check the behaviour of the brake lining during the cooling process. This, in turn, demands that further brake applications are made and measurements taken. Since it is necessary to interfere as little as possible with the cooling process, these brake applications are normally made from a reduced speed so that only a small amount of energy is transmitted through the brakes. The recovery stops for a private car would probably be made from about 30 m.p.h., a speed quite adequate to give the required accuracy of measurement. They would be conducted on an expanding time cycle, for example, 6 stops from 30 m.p.h., at 1 minute intervals, followed by 6 stops from 30 m.p.h. at 2 minute intervals, and so on. This provides a reasonable number of experimental points during the initial rapid cooling, and then maintains a roughly similar temperature decrement as the temperature approaches closer to the ambient and cooling becomes slower. During the course of these stops the performance of the friction material ought to return rapidly to the value determined by the cold performance test appropriate to 30 m.p.h., and it should do so without passing through this value and showing temporarily high friction, or over-recovery. Such over-recovery can be dangerous because brakes are generally more sensitive to friction changes at high than low temperatures and, as has been mentioned before, it is most unlikely that all four brakes of the vehicle will cool at the same rate and therefore the over-recovery condition could be reached on one brake first and cause erratic behaviour of the vehicle. Another undesirable feature, which may be shown by the recovery stops is the so-called delayed fade also previously described.

For a good frictional performance with regard to fade resistance, the requirements can be summed up as adequate fade resistance so that the pedal will not become heavier during the normal brisk motoring, followed by a gentle and progressive fade so that the pedal will become progressively heavier if the brakes are overworked. The driver will then be warned, and will also find the effort of further rough treatment very tiring. This progressive fade with increase in temperature above a certain high level is desirable, as otherwise it is possible to push more and more heat into the brakes and encounter troubles due to brake fluid vaporization or burning of the oil seals. In either case a sudden and complete loss of braking results, which is obviously much more dangerous than the development of a progressively heavier pedal application.

Fade tests on a heavy vehicle are normally conducted in a rather different manner. It is not usually possible to put the required amount of energy through the brakes of a heavily laden vehicle by accelerating and braking on a level road. The criterion for such a vehicle is its ability to make several descents on relatively long hills; it is therefore customary to select some particular hill with a careful eye to safety in the event of any fade occurring, both for the driver and for other road users. As the hill is descended, brake applications are made at certain pre-determined points to bring

the vehicle to a standstill, the energy of the descent adding to the normal kinetic energy absorbed in stopping the vehicle. At one or more of the points a check is normally made to determine if the hand brake will hold the vehicle on the required gradient; at this stage it is often useful to turn the vehicle round and ensure that the hand brake will also hold the vehicle when pointing up the slope. Recovery tests can be conducted as with the private car.

In detail, the fade tests adopted by different vehicle and brake manufacturers show considerable variations, although the tests all follow the principles outlined above. In devising such a test it should be realized that it is all too easy to destroy a brake system by imposing a ridiculous duty upon it. The fade test is intended to ensure that the brake will maintain reasonable efficiency throughout any type of road service. Unless the test conditions do, in fact, represent some form of road service, they may lead to the adoption of a brake lining that is not based on the usual compromise between docility in general use and resistance to abuse. This will lead to endless trouble for the vast majority of motorists, because the consequent lack of latitude in the design of a brake lining prevents adequately smooth and silent braking under light and normal duty conditions. Great care is therefore required in the preparation of a fade test schedule.

Many fade test schedules are based upon estimated Alpine conditions, and in this respect the author has made measurements[2] to compare Alpine braking with that encountered on the English roads in the Peak District. If a car is driven gently, the braking conditions do not differ very much with the terrain, but as the mean speed rises Alpine motoring involves greatly increased numbers of stops and greatly increased energy dissipation. At a mean speed of 35 m.p.h. on one particular motor car the work done at the brakes per mile on the Alpine pass was four times greater than that on the Pennine hills. When, however, the car was driven at the maximum safe speed on each route, the energy dissipated per mile by the brakes was almost the same in the two cases, although for this amount of energy dissipation much higher mean speeds could be maintained on the English hills. This suggests that hard driving in Britain can be as arduous for brakes as correspondingly hard driving in Alpine terrain. An analysis of the results also shows that, taking into consideration the effects of engine drag and other retarding forces, the equivalent to this maximum duty would be given by out-of-gear stops from about 50 m.p.h. to 30 m.p.h. on a 22 second cycle. The cycle time used in the fade test, shown in Fig. 7C, is therefore reasonably representative of fast Alpine motoring, but the energy dissipated is roughly twice that indicated by the author's measurements; in fact it would correspond with an overall average speed of about 45 m.p.h., which is appreciably faster than the speeds maintained on Alpine roads even in the major international rallies. This test is therefore representative of a duty considerably more severe than any road service, even in competition motoring, and can only be regarded as being designed to observe the break-down point of the brake system. Provided that the test is interpreted with this in mind it can, however, be a most useful yardstick for assessing development.

Water Recovery Tests. Vehicles likely to be used in rough country, military vehicles and trial specials for example, and some types of heavy vehicles used in earth moving, must have a braking performance that remains reasonably constant even after semi-immersion of the brakes in water. This requirement also affects the family saloon car, because of both the export of such vehicles to some of the wilder parts of the world and our own wet climate.

The presence of large amounts of water in the drum tends to provide a lubricating action, which generally results in temporarily low friction. This should, however, be of extremely short duration and should be coupled with a smooth resumption of the normal frictional behaviour without any temporary high friction, such as can easily arise when the bulk of the water has gone and the linings are left in a slightly damp condition. To check the behaviour in these circumstances, the vehicle is made to do a succession of stops from low speed on a level road, and the deceleration for a normal pedal effort is observed. The recovery of the lining from its immersion in water can then be assessed by the sequence of deceleration readings obtained.

General Road Mileage. In order to determine its road characteristics, a brake lining must be used in a normal manner for considerable mileages, although under these conditions it is impracticable to get more than a subjective impression of the performance of the brakes. The tests already described suffice to provide factual evidence of the behaviour of the lining and should be repeated at varying stages throughout the life of the material. Usually, the procedure is to drive the vehicle in a normal manner for a few hundred miles to ensure that the lining is fully bedded to the shape of the drum, and then to remove the shoes so that initial measurements for weight and thickness loss can be taken. Then the linings are refitted, and shortly afterwards the vehicle undergoes a performance test to show the behaviour of the linings in their early life. A distance of approximately 500 miles is then covered at a reasonably high speed so that the brakes are worked fairly hard; at the end of this time, the frictional performance is again checked by means of a performance test. At this stage the other tests outlined above can also be conducted. In the course of the driving, observations can be made on the general performance of the lining with particular reference to squeal or other forms of noise, sharpness or grabbing of the brakes or any other form of irregular braking. The general feel of the brake in the hands of an experienced driver can often indicate features which might not be clearly evident from performance tests.

After the tests have been conducted, further mileages should be completed and at intervals the drums should be examined for heat spotting, and scoring; and the general condition of the linings should be assessed and measurements taken. The performance tests and possibly fade tests should be repeated at intervals throughout the mileage covered. It is difficult to state with confidence how far it is necessary to continue the test, since the requirements in this respect differ to some extent according to the type of lining, but it is safe to say that a good lining should exhibit uniformity of performance by the time it has covered about 500 miles and has been put through a fade test. A mileage of 1,000 to 3,000 miles is generally desirable to ensure that this stability has in fact been attained; it is always posssible that some slight changes might occur towards the end of the life of the lining, but these would generally be associated with a slight acceleration of wear rate rather than with any frictional misbehaviour.

Field Tests

Scores or even hundreds of experimental linings may be tested before the friction material manufacturer feels that he has a lining suitable to add to his range of established qualities, or to replace an obsolescent lining. When such a lining has been found the controlled testing within the organization must then be extended by general testing in the field. Where the lining is intended for use on a vehicle in quantity production, the vehicle manufacturer and the brake manufacturer will both conduct extensive tests, generally in the process of the development of a new model. In the course of these tests an appreciable number of sets of brake linings will normally be worn out.

If the advent of the new lining does not happen to coincide

with the development of a new model, the testing of the lining is often organized on a wide range of different vehicles, so that the capabilities of the lining can be fully assessed. These tests are generally under the control of the brake or vehicle manufacturer, although co-operation is always maintained with the friction material manufacturer. If the new brake or clutch lining is finally adopted by the vehicle manufacturer for standard equipment on his motor cars, the new material will have had to satisfy first the friction material manufacturer, secondly the manufacturer of the brake or clutch assembly, who is responsible for the overall behaviour of the unit, and thirdly the vehicle manufacturer who, in turn, is responsible for all the components that constitute the motor car. The new material will, therefore, have been tested extremely thoroughly under a wide variety of conditions, probably on many different designs of vehicles and certainly at the hands of a number of different operators. All these tests will have been conducted under conditions of more or less careful control by personnel skilled in the operation of such tests.

This latter situation does not always apply when the friction lining is to be employed in a vehicle that is not in quantity production. In particular, friction linings for fleet operators and also for certain customers in the export markets are chosen by the operators themselves on the basis of their own field tests. These operators will also often conduct field tests on new qualities, although this might involve them in certain costs; this is because in the long run they will benefit by any improvements they may find in the new linings. When conducting field tests under these conditions, the chief difficulty is to establish a satisfactory control test. It is desirable that the number of test vehicles equipped with the new lining should be similar to that equipped with the lining that has been used previously. These should then be operated with either a planned or a completely random interchange on the different routes and services worked. Directly comparable results can then be obtained between the new and old linings. Unfortunately, this is not always possible, because the vehicles are, in any case, in normal daily use and cannot always be withdrawn for relining, switching to other services, etc., as might be desired. All too often it is found, on the comparison of a new field test with the fleet average, that the lining appears good or bad because of the mildness or severity respectively of the particular routes on which it has been used. So many variables in terms of routes operated, types of vehicles, types of drivers, times of the day and of the year, can affect the severity of duty on the brakes that a carefully chosen control test is worth the trouble and difficulty it causes.

Field test results have inevitably to be sifted with great care and generally analysed from a knowledge of the operating conditions and sometimes the personnel involved with the different fleets. Certain operators quickly obtain a reputation for reliability, and test results obtained from these are given great weight. On the other hand other operators, possibly through no fault of their own, are unable to keep a careful check on the behaviour of certain vehicles, and errors can easily arise if careful records cannot be kept of the use made of the vehicle and the service on which it is used.

In spite of these difficulties and criticisms, a great deal of extremely valuable information is obtained through the good offices of the fleet operators and, when analysed with care, the results do in fact form the final judgment on the brake or clutch lining, the ultimate criterion being whether or not the customer wishes to buy that quality.

In connection with field testing, mention must be made of competitive and racing motoring. Many arguments have occurred as to whether any useful information is obtained from competitive motoring; nevertheless it can scarcely be disputed that the conditions under which the brakes operate, by virtue of the increased severity of duty, do represent a useful overload test on normal linings. This type of motoring also leads to the development of special linings of high temperature resistance, which later find certain, if not widespread, application in general service. The development of the automotive disc brake and the friction materials with which it operates has taken place largely on racing and sports cars. Now, the knowledge obtained is being applied to a number of cars of wider appeal and also to vehicles in the heavy range. For this reason, careful attention to the performance of friction materials in racing and competitive motoring can help with the problem of field testing a new quality, especially as the components of a racing car are invariably pressed to the limit and therefore their manufacturers are generally only too keen to try any new developments in the hope that they will give them that marginal superiority they require over their competitors.

Instrumentation for Test

One of the virtues of machine testing, whether on laboratory scale or on the full scale inertia dynamometers, is that careful instrumentation can be used and a great deal of information obtained on the behaviour of the friction material. On the vehicle tests, simple instrumentation of the type already outlined has generally proved to be the most effective although, for certain research projects, quite ambitious equipment has been fitted to a motor vehicle, Figs. 8 and 9.

The basic problems in the instrumentation of test machines are three-fold; first, the recording of the normal pressure exerted between the lining and the drum; secondly, the recording of the drum drag or the braking torque generated; and thirdly, the indication or recording of the temperatures reached during the test.

If the hydraulic brake is used, it is relatively simple to

Fig. 8. Four-pen high-speed recorder mounted in a Triumph TR2 for a special investigation into the duties imposed upon brakes in various types of service. This work was undertaken to provide a firmer basis for drawing up the schedules and procedures for the test machines

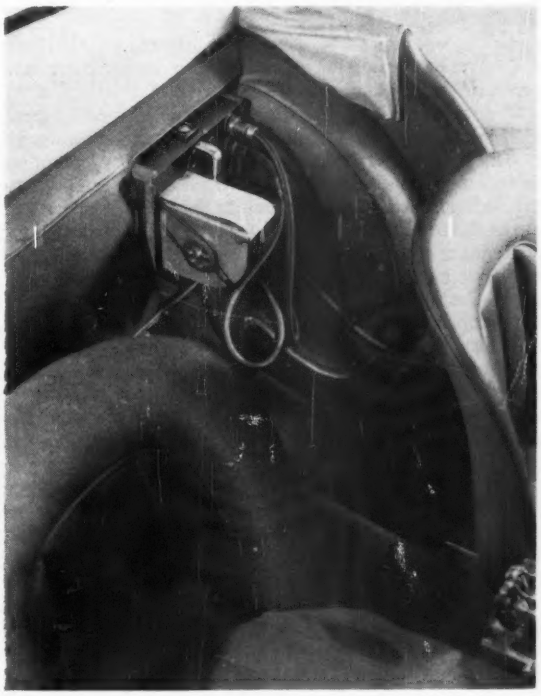


Fig. 9. Another illustration of the Triumph TR2, showing more of the special instrumentation; the speed signal generator in the middle foreground was normally shielded by a metal cover. Under the passenger's feet is a battery to drive the electronic calculating units that were used to provide the appropriate recorder traces of the measurements taken

record the pressure applied to the wheel cylinder, either by means of a Bourdon tube recorder or, if high response is required, by a strain gauge cell or some such piece of equipment. On the other hand, if the brake is cam operated, it is usually possible to actuate the lever by means of air or hydraulic equipment, so that the same type of recording can be used. From the cam and lever ratios, the normal pressure on the lining can be assessed.

The recording of the torque can also be effected by means of a hydraulic system, if the back-plate of the brake is mounted in bearings on a shaft and the torque transmitted to an arm at right angles to this shaft, Fig. 2. This arm rests on a piston in a cylinder containing hydraulic fluid, and the pressure in the fluid is indicated on a Bourdon tube recorder. As an alternative, strain gauges can be used to record the torque: these can be fitted to the torque arm, which acts as a beam; alternatively, the rear end of the torque reaction shaft can be clamped and strain gauges can be used to indicate its torsional strain.

Assessment of temperature in brake testing is an extremely complicated and difficult matter[6,7,8]. The temperatures that occur at the inter-face between the friction material and the drum are transient in nature and, so far, no means has been discovered of assessing their real value. Roughly, the position can be summarized as follows. Acting as a heat reservoir, the bulk of the drum is raised in temperature to a level determined by the general balance between the rate of heat in-put and the rate of heat loss over some appreciable period of time. As the working surface is approached, gradients are superimposed upon this bulk temperature. These gradients depend directly upon the rate at which energy is being dissipated at the surface: in other words, heat is being forced into the drum, the gradients being determined by the heat transmission requirements. The temperature reached at the inner surface depends therefore upon the bulk temperature of the drum and the excess required to drive the heat into the drum at the appropriate rate. This latter figure is dependent entirely upon the rate of working on the brake and the time from the beginning of the brake application, because the temperatures at the surface build up as the gradients develop into the thickness of the drum. This state of affairs applies except at the microscopic surface layers of the drum and lining, where the conditions are indeterminate because contact between the drum and the lining generally occurs only in localized areas which are quickly worn away to allow other areas to contact. Local gradients, therefore, occur in the surface skin of the lining, where extremely high temperatures arise at the actual areas of contact. The mechanism of the frictional wear has been discussed elsewhere, and several alternative theories tendered to account for the mechanism of wear but, whatever the actual form, there is no doubt that intense transient temperatures arise in the lining. Since these occur at the rubbing surface, they obviously have a considerable influence on the behaviour of the friction material.

Although it is not yet possible to measure these true surface temperatures, they can, however, be reproduced on the test machines. If a lining is made to fulfil the appropriate range of duties, under cooling conditions and over time cycles similar to those occurring on the road, then the microscopic surface conditions should be reproduced. Thus, so far as temperatures are concerned, the most important feature with regard to testing of friction materials is the reproduction of the correct levels rather than an exact knowledge of their values.

Several methods are available for the assessment of the temperature of the drum in general service. The simplest of these is the use of thermal paints, which change colour when a certain temperature is reached. If a range of such paints is put on the outside of the drum and the change points noted, a temperature curve representing the maximum temperatures reached at these various points can be determined. If the test machine is then made to reproduce the

Fig. 10. This illustration shows another of the test machines and the complex control and recording gear that has been specially developed by Ferodo to ensure accurate reproduction of service conditions

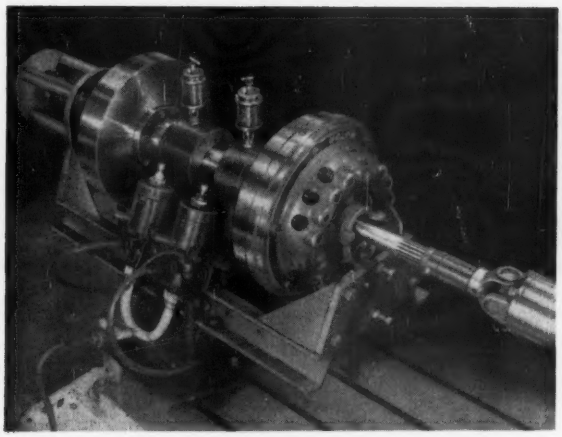


Fig. 11. Machine for testing automotive clutch facings. An electric motor on the right, not included in the picture, drives through the clutch and accelerates the flywheels, which are then braked to a standstill by another clutch behind the second flywheel. This procedure is repeated many thousands of times on a controlled time cycle

torques and cycles that occur in service, and the fan cooling is so adjusted as to produce similar temperature curves on the outer surface of the drum, the conditions within the drum should be reasonably similar to those occurring in service.

The assessment of wear, as already stated, is normally made by observing the weight and thickness loss of the samples after a certain amount of duty. A pre-requisite of any comparative wear assessments, between different friction materials, is that the samples should all be subjected to the same conditions in terms of temperatures, rubbing speeds, amount of work done, etc. It is easy to satisfy most of these conditions, but the temperature will only be reproduced accurately provided that the lining is not only subjected to the same amount of work but also worked at the same rate as its fellows. This in turn means that the braking torque rather than the application pressure must be controlled, otherwise a brake lining that shows any tendency to fade during the course of the test will work at a reduced rate because of the fall in torque and, although the same amount of work will be done within the cycle, the reduced rate of working will affect the surface temperature gradients. Similarly, a material whose friction increases with temperature is seriously penalized in terms of the wear assessment. These features are avoided if some type of torque control unit is employed to vary the pressure so as to maintain a constant braking torque and hence rate of working. This is not difficult with the constant rubbing machines but on the inertia test machines, owing to the sudden application of the brakes and to the short stopping time generally encountered, the problem of torque control is extremely difficult. Suitable control systems have, however, been developed both in this country and in the United States.

The author wishes to thank the Directors of Ferodo Limited for permission to compile and publish this article.

References

1. N. CARPENTER: "Some Measurements of Brake Usage in a High Speed Saloon Car," Proc. I. Mech. E. (Automobile Division), 1956.
2. N. CARPENTER and A. P. LEES: "Automobile Brake Usage under Practical Conditions," Proc. I.M.I., 6th International Congress of F.I.S.I.T.A., 1956.
3. H. J. H. STARKS: "The Deceleration Obtained by Car Drivers When Braking on the Road," D.S.I.R. Road Research Laboratory, Research Note 1,724, 1952.
4. M. PLATT: "Automobile Brakes and Brake Testing," page 43, *Pitman*, 1947.
5. H. J. H. STARKS: "The Braking Performance of Motor Vehicles and Brake Testing," Road Research Technical Paper No. 26, 1953.
6. G. A. G. FAZEKAS: "Temperature Gradients and Heat Stresses in Brake Drums," S.A.E. Trans., vol. 61, p. 279, 1953.
7. R. C. PARKER and P. R. MARSHALL: "The Measurement of the Temperature of Sliding Surfaces with Particular Reference to Railway Brake Blocks," Proc. I. Mech. E., vol. 158, p. 209, 1948.
8. E. C. TOGHILL and H. T. ANGUS: "Cast Iron Brake Drums," Automobile Engineer, vol. 43, p. 409, 1953.

CAST CRANKSHAFTS

American Developments in Shell Moulding

In America, Ford Motor Co. first introduced cast crankshafts in 1933. Dry sand moulding was employed in conjunction with an arrangement for producing four castings from a ferrous alloy with 1·5 per cent carbon. Not only did the casting process permit greater flexibility in design, but it also eliminated straightening and heat-treatment operations and greatly reduced the machining operations that had been necessary on forged shafts.

Experience with the cast crankshaft since its introduction suggested that it would be advantageous: (1) to provide a continuous supply of molten metal to allow replacement of the batch process, and (2) reduce further the machining allowances typical of those required in normal casting. These improvements have been effected by the adoption of shell moulding based on the application of a mixture of sand and thermosetting resin to a preheated pattern. Shell moulds for crankshafts are made on individual shell-making machines mounted on a large turn-table so that the entire operation is performed during a single rotation of the turn-table. A pair of shells are joined together by spring-loaded clips, and the assembly is inserted into a flask mounted on the pouring line. The flask is conveyed to the loading station where arrangements for the support of the thin shell mould are made, the flask then continuing to the pouring station, where previously prepared nodular iron is poured into the mould.

In the foundry, the shell-moulded crankshaft has the advantage of permitting a high degree of automation. Very close tolerances are maintained from casting to casting, and not only are crankshafts near-perfect dimensionally, but also quality-control procedures can be effectively used for inspection, gauging, and metallurgical examination. Raw-sand requirements are reduced from 125 to 20 lb per casting, less pattern maintenance is required, and foundry working conditions have been vastly improved. The rough crankshaft, as delivered for machining, is distinctly superior to that made by any other method; finishing stock has been reduced from 9·5 lb in previous casting procedures to 5·5 lb in shell moulding. Closer tolerances facilitate the balancing operation; the centring operation has also been simplified and tool maintenance reduced.

Engineering advantages of the shell-moulded crankshaft include very high wear resistance attributed to the self-lubricating action of free graphite on the bearing surface. Exceptional endurance results from improved damping characteristics, the absence of casting defects, and the combination of sound design and good manufacturing procedure. The high precision permits flexibility in design, while improved, consistent balance is attainable at minimum cost.

AUTOMATIC FLAME-HARDENING

Adaptable Machines for Continuously Controlled Operation in the Production Line

Etched section of a cam hardened by the oxy-town gas flame process

UNDER modern conditions of production, the surface hardening of metal components may involve an interruption of the flow method since the period of time required for hardening, by most processes, is considerably longer than the cycle time of the production line. In such circumstances the work is withdrawn from the line and is batched through the hardening process, to be returned later to the line for further machining operations or, in some cases, passed directly to an assembly line. However, equipment is now available to allow some hardening processes to be carried out in the production line. Flame-hardening, for example, is being used on an increasing scale because it is an extremely rapid process and can be readily arranged for automatic operation and control.

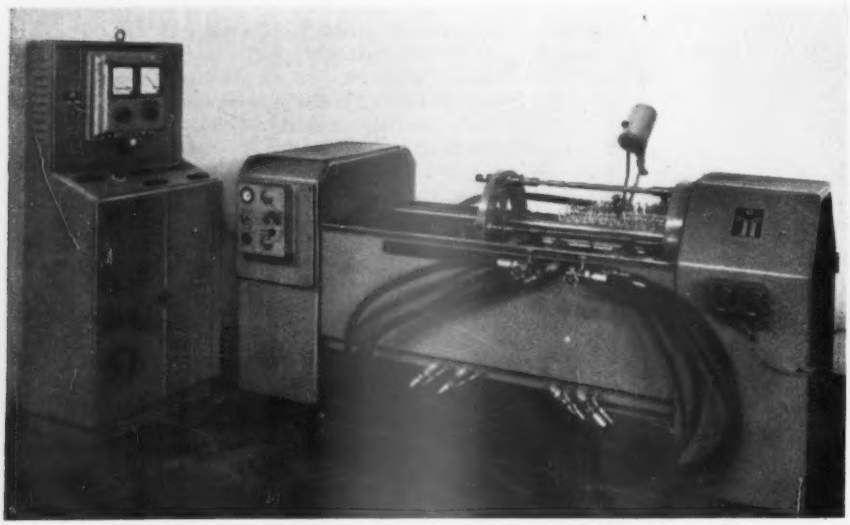
Various fuel gases have been employed for flame-hardening but the use of oxygen and town gas was pioneered by the firm Paul Ferd. Peddinghaus, of Gevelsberg, Westphalia, Germany. Several advantages are claimed for this combination as compared with a fuel of oxygen and acetylene. Used in the proportion of 100 ft^3 of town gas to 60 ft^3 of oxygen, the flame temperature is well above the hardening temperature required for steel components but is from 800 deg C to 1,000 deg C lower than an oxy-acetylene flame. This lower temperature safely permits much greater tolerance in the control of the process of surface hardening.

Experience has shown that 90 per cent of the oxy-town gas is consumed at the orifice of the burner, while with oxy-acetylene it is possible to consume only about 25 per cent at that point and the remainder is burned in the secondary air away from the burner and to little effect. It follows that the oxy-town gas flame is small in volume and the loose-flame characteristic of oxy-acetylene is completely absent.

Flame-hardening will give satisfactory results with most carbon and alloy steels having from 0·30 to 0·70 per cent carbon, and with cast irons having small graphite flakes and a relatively low phosphorus content. The degree of hardness attained is closely related to the carbon content of the material, but the depth of hardening can be readily varied. The process has, of course, been practised for years but early methods were dependent entirely on the skill and care of the operator and, consequently, carried the risk of inconsistent results and the scrapping of valuable machined components.

The use of an oxygen-town gas flame, and the application of reliable flowmeters for the oxygen and the gas, materially reduced these hazards. With the introduction by Peddinghause of the Milliscope instrument,* automatically controlling the process by holding the temperature of the

*"*Automobile Engineer*," October 1955.



Type NWA machine complete with control cabinet. With automatic loading and unloading equipment the cycle time for a knurled shaft 1 in diameter × 24 in long is 30 sec

work to the specified value, the human element was eliminated and the process could readily be mechanized and incorporated in a production line. With an oxygen-town gas flame and automatic control, the risks of overheating or unevenly heating the work are obviated and distortion is virtually eliminated. Hardened parts may in many instances be passed directly to the assembly line but, where finish grinding is deemed desirable, only the minimum grinding allowance is necessary.

There are four principal methods of flame-hardening and a wide range of machines has been developed by Peddinghaus so that most types of component, either large or small, can be rapidly and economically hardened.

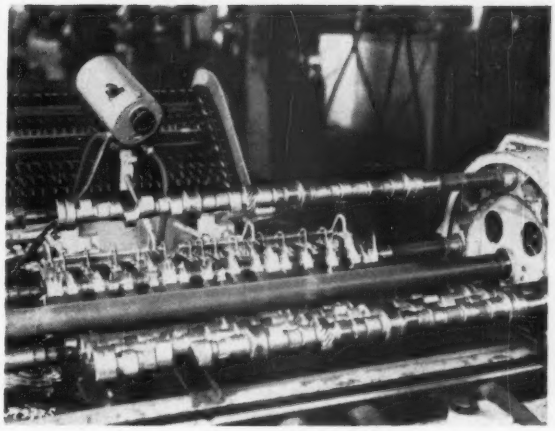
Progressive method

A burner, or a plurality of burners arranged to suit the profile of the work, followed by a spray quench, moves progressively over the surface to be hardened or, alternatively, the work may be moved past a stationary burner and a quench. Wheel-shaped bodies are rotated below the burner and its associated quench. The teeth of large straight or helical gear wheels, bevel wheels, or sprockets, are hardened by traversing the burner and quench over each tooth and indexing the wheel tooth-by-tooth. When used to harden the slideways of machines, machine tools, or other work of varying section, the Milliscope is focused on the moving hot zone produced by the burners. Should a change of temperature in this zone be registered, the Milliscope control automatically adjusts the rate of progress of the burners, either accelerating or decelerating them in order to maintain a virtually constant temperature. Machines operating on this method are equipped with flow-meters for oxygen and gas, and an infinitely variable speed drive. Automatic indexing can be incorporated, with a stop switch to terminate operation when the indexing cycle is completed.

Spinning method

The component is rotated between burners of suitable width and shape to cover the hardness pattern required. When the temperature has been raised to that preset on the Milliscope, the component is either moved automatically from the heating station to the quenching station or is lowered into a quench tank. This method is suitable for accurately hardening a wide range of components on a production basis. Crankshafts, camshafts, spindles, bolts, gears, cluster gears, ring gears are examples currently being rapidly hardened at low cost. The total cost of fuel and quenching water for the crankshaft of a twin-cylinder diesel engine, two pins and three journals, is one shilling.

Depth of hardening can be accurately controlled by adjustment of the rate of heat input, thus varying the time required for the component to attain the hardening temperature. The lower the rate of heat input the longer the time required and, consequently, the deeper the hardness pattern. This method has recently been further developed to harden relatively large diameter transmission gears, such as the final drive gears of tractors. It effects a substantial reduction in time and eliminates distortion. Peddinghaus automatic machines for simultaneously hardening the journals and pins of crankshafts for four- and six-cylinder diesel engines by this method, installed at the Lincoln works of Ruston and Hornsby Ltd., have been described in an earlier issue.†



Drum fixture of NWA machine set up for hardening a six-cylinder diesel engine camshaft. Cycle time 40 sec

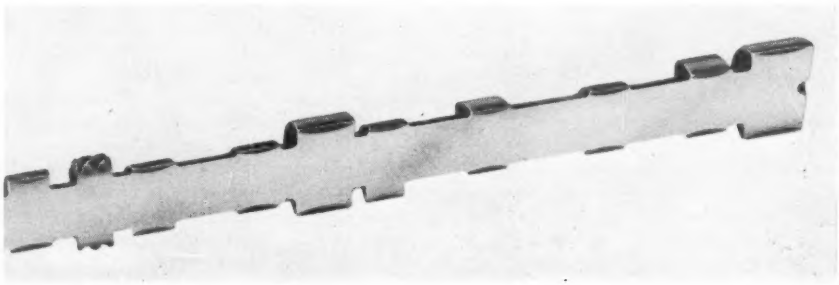
Combined method

Single components, such as shafts or spindles having a relatively high ratio of length to diameter, are rotated between burners and following quenches which traverse the length of the surface to be hardened, as in the progressive method. The rotation of the work ensures the concentricity of the hardened zone. Machines of different capacity in horizontal and vertical types are available. They can be equipped for the internal hardening of the bores of symmetrical components.

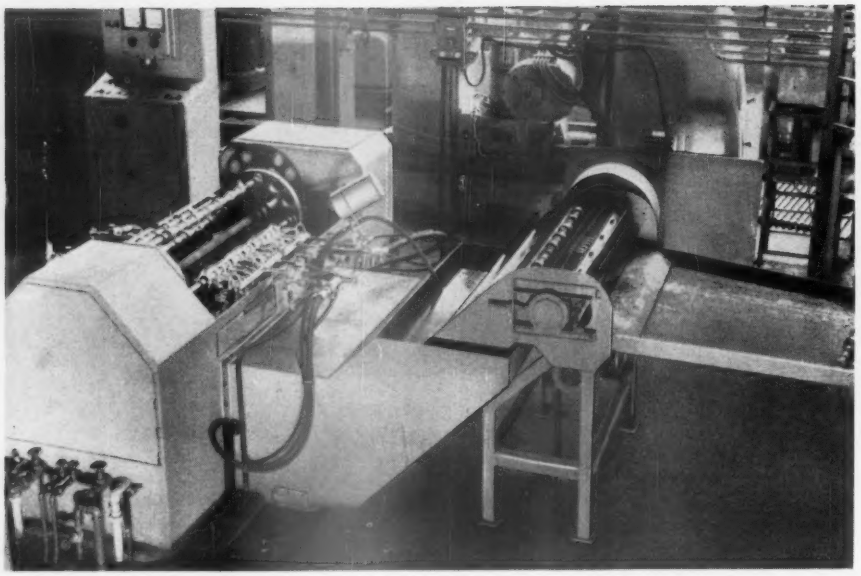
Spot method

Small parts, or asymmetrically shaped components requiring one or more hardened zones, may be jig-located on a multi-station table and indexed automatically for loading, heating, quenching and unloading. High rates of output can be attained with such items as valve rockers, rocker adjustment screws, ball-end studs, tappet ends, selector forks, and tractor track links.

†"*Automobile Engineer*," *September* 1955.



Part of a six-cylinder diesel engine camshaft sectioned and etched to show consistency of hardening treatment



NWA machine in the production line at the works of a German automobile manufacturer. Camshafts for a six-cylinder engine, with seventeen hardened zones, are treated in a 40 sec cycle. The hardened shafts are elevated from the catch basin and discharged on to a conveyor delivering them to the grinding station

Camshaft hardening machine

Specially developed for automatically hardening steel or cast iron camshafts, the type NWA machine is also adaptable for similarly proportioned components such as axle shafts, splined shafts, or gear shafts on which specific areas are required to be hardened. Parts to be treated are fed by gravity down an inclined chute from a magazine and are mechanically loaded, one at a time, into a four-station rotatable drum fixture. When received in the drum, the shaft is picked up by a sliding back centre and fed axially into one of the collets of the four-spindle driving head and secured for spinning. The fixture then indexes, carrying the shaft to the burners at the heating station. Here, as the shaft is rotated, the heated zone is under the observation of the Milliscope instrument and, when the desired temperature has been attained, the instrument trips the indexing mechanism and the shaft is carried to the spray quenches at the next station. Incidentally, the burners for the cam surfaces, like those for the journals and the timing gear, are adjusted to a fixed position and do not follow the cam profile. The protruding nose of the cam passes through the hottest zone of the flame into a relatively cooler zone and thus is not overheated.

A small refinement of the operating sequence is introduced at this stage. In order to ensure an even quenching action the water sprays are momentarily cut off while the indexing movement is in progress. When the drum is next indexed the quenched shaft is released, ejected and discharged down an inclined chute to a bin, a conveyor, or a transfer line.

Where the parts are of an alloy steel, requiring quenching in an oil emulsion, the machine is equipped with a catch basin for the quenching medium. The heated and quenched part is discharged into the basin from which it is subsequently lifted out by an elevating conveyor. A cooling unit is built into the machine to maintain the quenching medium at a correct temperature. For automatic operation in a production line the machine is indexed either by the Milliscope instrument or by a time relay. For small batch production the indexing can be manually controlled. Control switches and gauges are grouped in a cabinet that can be located for the convenience of the operator. From the gauges for pressure and flow the adjustment of the burner flame can be checked and a record can be filed to reproduce the conditions on a subsequent batch of parts.

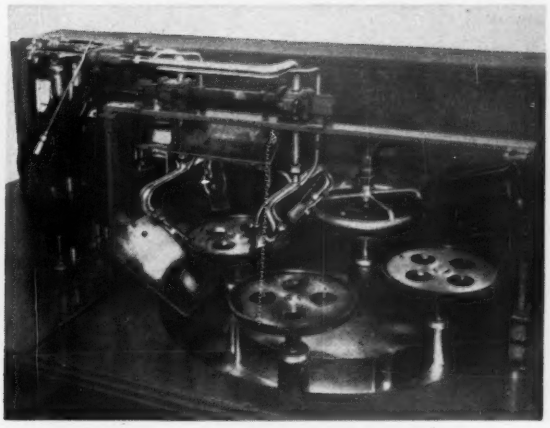
This machine which has a plan area of 79 in × 36 in, can accommodate work up to 3 in diameter, or 40 in long, or a weight of 13 lb. Typical cycle times are 40 sec for a six-cylinder diesel engine camshaft, with four journals, twelve cams and a timing gear, and 9 sec for a rocker shaft, having eight hardened surfaces $\frac{3}{4}$ in diameter × $1\frac{1}{8}$ in long. Fuel consumption per part is 32·4 ft^3 town gas and 19·4 ft^3 oxygen for the camshaft, and 4·8 ft^3 town gas and 2·9 ft^3 oxygen for the rocker shaft. These machines are currently being used for camshafts by the Daimler-Benz A.G. in Germany.

Gear hardening machines

The spinning method is used for hardening gears of all types, including ring gears and cluster gears, and also for such parts as clutch hubs or drive flanges. Since by the spinning method all teeth of a gear are heated simultaneously, each tooth is hardened right through. Consequently, the process is applicable only to gears made of a material that remains sufficiently tough when through-hardened. Suitable gear steels are En 8M, En 10, En 24 and En 48.

The shape and size of the gear is of minor importance provided that it is so designed and mounted that the rim can be uniformly heated and that the burner capacity is matched to the dimensions of the gear. According to the duty for which the gear is intended and to the working stress to which it will be subjected, the depth of heat penetration must extend close to the root circle, or even below it. However, overheating of the tips of the teeth must be avoided. A pressure gauge and flowmeter unit for adjusting the burners is essential for consistency of results, and the Milliscope can be arranged to operate a chart recorder to produce a record of the complete cycle for subsequent reference. One machine for this purpose has four vertical spinning spindles in an indexing table and can handle ring gears up to 10 in. diameter. Loading and unloading are performed manually and the machine is fully adjustable to accommodate any circular work up to the maximum diameter capacity. Thus, it may be used as a general-purpose machine on batch production, or can be

Automatic hardening of small parts by the spinning method. With magazine feed the through-put may be up to 900 per hour



Four-spindle indexing work table of ZKU cabinet type machine for spin-hardening gear wheels up to 10 in diameter

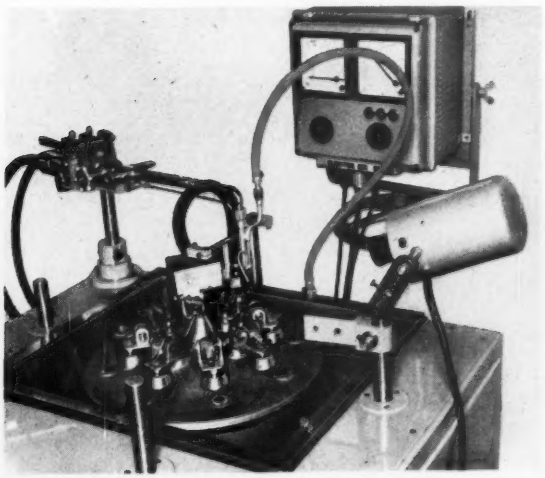
set up permanently as a special-purpose machine in a production line.

It is a self-contained, cabinet type machine incorporating all necessary pressure gauges and flowmeters, and equipped with a Milliscope control instrument. Since an oil emulsion is usually employed as the quenching medium, a catch basin is provided and the medium is pumped through a cooling unit and recirculated. The work table is indexed by the Milliscope, or on a time basis, and the part is moved to the heating station and spun in the flames of two, three, or four spaced burners, according to the diameter and section of the part. On reaching the required temperature it is indexed to the quenching station and rapidly cooled under a continuous ring spray. The two other stations are for unloading and loading. Cycle time will vary with the size, mass and character of the component being treated. For example, production capacity is 260 per hour for a 10 in diameter starter ring gear, 130 per hour for an 8 in diameter ring gear of heavier section, 100 per hour for a $2\frac{3}{16}$ in diameter splined drive flange, and 82 per hour for a $3\frac{1}{8}$ in diameter clutch hub. The floor space occupied by the machine is 118 in × 53 in.

Another gear hardening machine, the ZHS, can handle gears up to $17\frac{1}{4}$ in diameter and a face width of $3\frac{1}{8}$ in. Gears are treated individually on a single spindle and are dip quenched. Loading and unloading are by hand but the heating and quenching cycle is automatically controlled by a Milliscope. The gear to be hardened is mounted on the spindle, which can be raised and lowered hydraulically, and is rotated at 40 rev/min during the heating phase. The Milliscope measures the temperature of the heated zone and, when the preset value is reached, lowers the gear into the 242 gal capacity quench tank. Rotation of the spindle is stopped so that quenching occurs under optimum conditions.

The quenching medium, oil or a soluble oil emulsion, is cooled and recirculated by a pump at the rate of 7,700 gal/hr. As a maximum, the consumption of cooling water is 396 gal/hr. Electric thermometers give a continuous indication of the respective temperatures of the quenching medium and the cooling water discharge and are used to adjust the consumption of water to the most economical value. The cabinet to the right of the work zone houses the flowmeter and pressure gauge unit, the control gear, and the Milliscope head. All are accessible through the large door. Mounted to the left of the zone are the Milliscope indicator and, if required, the chart recorder. Side panels

Spot hardening the ends of overhead-valve rockers on the type AA machine. Output rate is 360 parts per hour



Spot hardening tractor track links on the type TA machine. Loaded and treated in pairs the output is 240 per hour

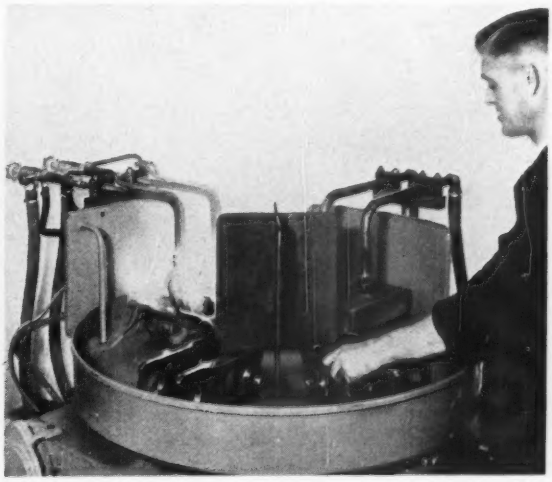


TABLE I—Distortion of 32-tooth, 8·5 D.P. gears flame-hardened by spinning method

Pitch error	Min. after machining Max. permissible	0·0002—0·0004 in 0·0008 in
	Before hardening Max. Mean After hardening Max. Mean	 0·0002 in 0·00008 in 0·00036 in 0·00008 in
Runout error	Max. permissible Before hardening After hardening	0·0012 in 0·00032—0·00063 in 0·00059—0·00087 in

TABLE II—Comparison of production times for case-hardened and flame-hardened gears

"Number off" corresponds to one furnace batch for case-hardening

Component	Number off	Time in minutes		Increase in output
		Case-Hardening	Flame-Hardening	
Spur gear 41 teeth 2¾ D.P.	10	2,160	400	5·4×
Sprocket 15 teeth Pitch line dia. 5½ in	36	2,880	240	12·0×
Bevel gear 25 teeth 4 D.P.	24	2,160	360	6·0×
Worm gear 2 D.P.	4	2,161	136	16·0×

are water-cooled to prevent heat radiated by the burners from penetrating to the interior of the machine. The space occupied is 87 in×43 in×63 in high.

Flame-hardening, by restricting the heating to the rim of the gear minimizes the risk of distortion. Commonly, it can be confined within relatively close limits, making it possible to dispense with a subsequent grinding operation. Cluster gears, which cannot be ground owing to the close proximity of the individual gears, if flame-hardened prove relatively quiet in operation by comparison with gears hardened by some other processes, by virtue of the reduced distortion. Table I gives the record of distortion on a batch of 32-tooth, 8·5 D.P. gears hardened on this machine. Table II shows the rate of hardening on different types of gears as compared with case-hardening methods. A larger version of this machine can harden gears up to 26 in diameter.

Spin hardening small components

Small symmetical parts, such as ball studs, tappet heads, adjuster screws and the like, not exceeding ¾ in diameter and 3 in long, can be spin-hardened on a small eight-station indexing machine, type AU. In general principles, it is similar to the multi-station spinning machine for gears. Suitable fixtures for the components are provided for the work table and indexing is initiated by the Milliscope immediately the required temperature is observed on the part at the heating station.

The heating of small parts is extremely rapid and the potentialities of the machine cannot be realized by manual loading. Accordingly, for continuous operation or long-run batch production it is usual to equip the machine with a magazine feed and automatic loading and unloading devices. Such a set-up for hardening ½ in diameter ball studs is illustrated, and the production rate is 720 parts per hour. Ball-ended adjuster screws for valve rockers can be hardened at the rate of 900 per hour. The output rate of these fully automatic machines depends on the time required for heating, the longest of the various operations. For rounds the heating time can be estimated approximately as 0·4 sec for each $\frac{1}{32}$ in of the diameter. The floor space occupied is only 40 in×34 in.

Spot hardening small parts

A machine basically similar to type AU, but without the rotating spindles and their driving gear, and designated type AA, is available for spot hardening selected locations on unsymmetrical parts. These components are usually unsuitable for magazine feed, so loading is effected manually and is necessarily slower than automatic loading. However, the provision on the indexing table of eight

Spin hardening a ring gear on the type ZHS machine. Control is by a Milliscope housed in the machine cabinet on the right and focused on the work through the aperture

stations, of which only two contiguous stations are occupied for heating and quenching, enables unloading and reloading of the fixtures to be performed with reasonable rapidity. Typical hourly rates of output are: two ends of gear shift fork 720, end of control lever 450, pad of side-valve rocker lever 360 and end of overhead-valve rocker 360.

Larger spin- and spot-hardening machines

For parts exceeding $\frac{3}{4}$ in diameter or requiring to be mounted vertically between centres, a larger multi-station spinning machine, Type TU, is available. This can handle rounds up to 4 in diameter and the maximum length between centres is 16 in. In design and operation it is similar to the type AU machine, but has either a six-station or four-station work table and is manually loaded and unloaded. Typical output rates are: front wheel-carrier axle, $1\frac{3}{4}$ in diameter, 180 per hour; splined shaft, $1\frac{1}{4}$ in diameter, 164 per hour; and spring anchor and shackle pins, 1 in diameter, 240 per hour.

A larger version of the type AA spot-hardening machine is known as type TA and can handle asymmetrical components weighing up to 55 lb each. Such items as track links are locally hardened on this machine. Smaller links can be treated in pairs to obtain a throughput of 240 per hour but with larger and heavier links, treated singly, the rate may be 60 per hour, due to the longer heating period required.

Where employed as general purpose machines, both the AU and the TU machines can be used for spot-hardening by stopping the spindle driving mechanism. The larger machines each require a floor space of 50 in × 40 in.

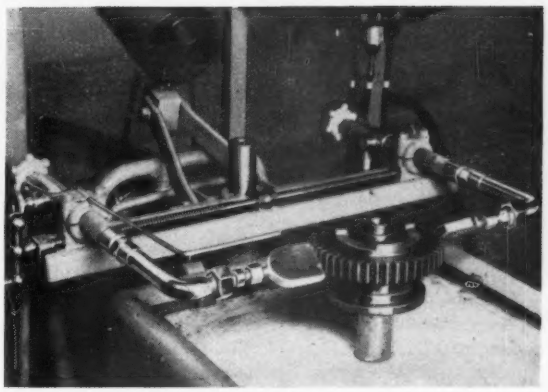
Vertical machine for shafts and cylinder liners

This machine, type SH, is produced in three versions. As single-purpose machines, versions A and B are, respectively, for the external hardening of shafts, axles and spindles, and the internal hardening of cylinder liners. Version BA is a general purpose machine equipped for both classes of work. Referring first to the external machine, work up to 5 in diameter is mounted between centres on the machine turntable and a tailstock adjustable on the slideways of the main column. The maximum length that can be accommodated between centres is $32\frac{1}{2}$ in, but shafts up to 47 in long can be mounted by substituting a steady rest for the tailstock.

The two semi-circular burners and quenches are mounted on a carriage slidable on the main column. This is operated hydraulically at a feed rate that is steplessly variable from 2 to 24 in/min, and is also provided with a fast upward movement at 177 in/min and a fast downward movement adjustable between 80 and 200 ft/min. Maximum traverse of the burner carriage is $27\frac{1}{2}$ in and the spindle speed is 110 rev/min. Thus, it will be noted, the machine can be used as is most suitable to harden different classes of work by the progressive, spinning, or combined methods.

Shafts can be treated by any of the three methods. Flat surfaces are hardened progressively by stopping the turntable drive. Tapered, shouldered, and flanged shafts or curved surfaces can be handled by using a template to guide the burners. In progressive or combined method operations, the Milliscope control accelerates or decelerates the rate of movement of the burners in order to maintain the work at the preset temperature within a tolerance of ± 10 deg C or 18 deg F.

Version B machine for hardening cylinder liners or the bores of other components is similar to version A in design, operation and control. The work, however, is located and secured on the turntable, and the burners and quenches are mounted on the lower bracket of the burner carriage (clearly visible in the illustration of the version A machine)



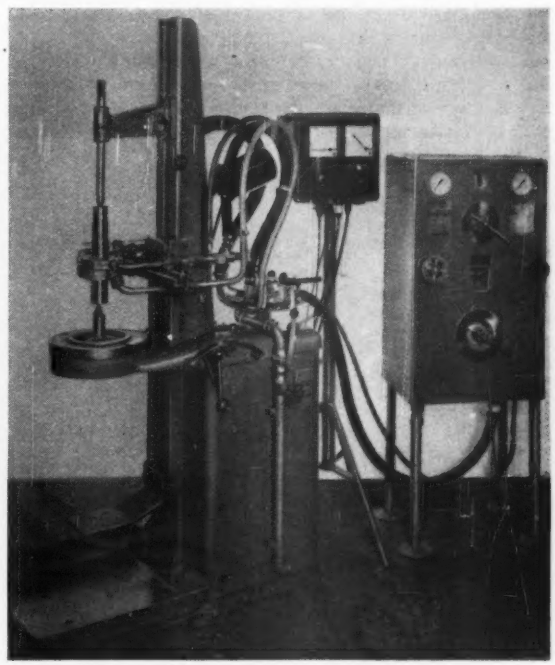
Single-spindle spinning machine for hardening gears of diameters up to $17\frac{3}{4}$ in. After being heated the work is automatically lowered into the quench tank

and are introduced into the work from below the turntable. As before, the maximum traverse of the burner carriage is $27\frac{1}{2}$ in. Bores up to a maximum of 8 in diameter can be treated.

The Milliscope control can be used for the internal hardening of cylinder lines and similar workpieces having a substantially constant wall thickness. In such cases the internal hardening temperature of the work always corresponds to an external temperature. This outer surface temperature can be used to control the inner temperature by suitably adjusting the preset value on the Milliscope.

All Peddinghaus flame-hardening machines and equipment are handled by Surfard Ltd., Abbey House, 2 Victoria Street, London, S.W.1.

A vertical machine, type SH, is available in two single-purpose versions; one for hardening shafts externally and the other for hardening cylinder liners internally



Delco-Remy Ignition Distributor

Notes on Basic Design and Production

FOR many years, the AC-Delco Division of General Motors Ltd., have produced a wide range of equipment for British cars and commercial vehicles. Hitherto, ignition distributors of high quality have been manufactured in small quantities, mainly for Rolls-Royce and Bentley cars, but the choice by Vauxhall Motors Ltd., of Delco-Remy ignition equipment for the Victor has necessitated an expansion of production facilities at the Dunstable works.

The new distributor, which is known as the D200 series, is the result of nearly four years' development work. Basically conventional in design, it has two features of particular interest, namely the construction of the housing and the design of the vacuum advance mechanism. In contradistinction to common practice, the usual cast iron housing has been abandoned in favour of a pressing in deep drawing steel, in which the lower end is pierced and plunged to receive a mild steel shank, which is copper-brazed to it. The shank locates in a machined bore in the cylinder casting of the engine and supports the drive shaft in a pair of sintered iron bearings. Oil-soaked felt washers fitted at the base of the housing, lubricate the upper bearing.

Immediately above the shank is the centrifugal advance assembly. This comprises a base plate fixed to the shaft and carrying the pivot pins for the two advance weights and posts for the control springs; an advance cam integral with the breaker cam above it, and a ribbed plate, which retains the advance weights. The sleeve on which the breaker cam is machined encircles the upper end of the drive shaft. Under the action of centrifugal force, the weights overcome the tension of their control springs, and rotate the advance cam and breaker cam relative to the drive shaft. This motion is in the direction of rotation of the shaft, hence earlier opening of the contact points is obtained. A felt wick, exposed when the rotor arm is removed, lubricates the bore of the breaker cam.

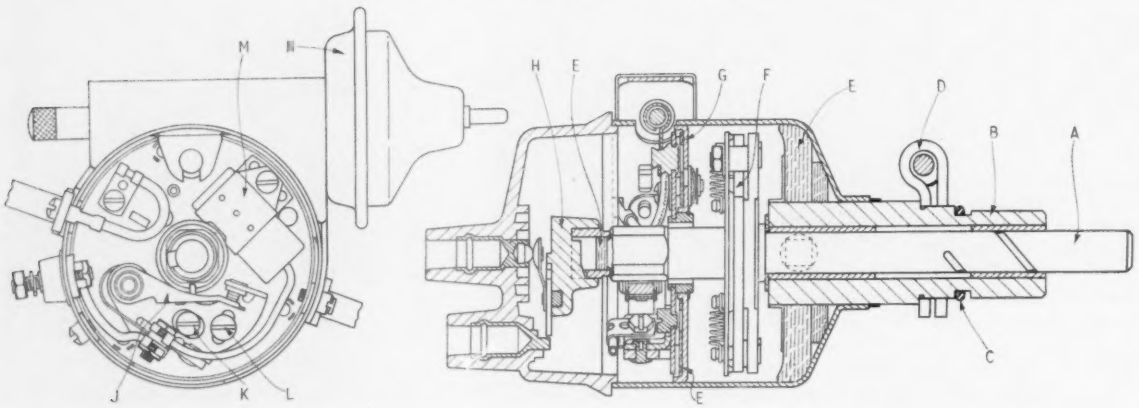
The contact breaker assembly encircles the breaker cam and is secured to the upper part of the housing by three screws. It has two main parts; the fixed breaker support plate and an upper movable plate, which carries the contacts and the condenser. Three equi-spaced, nylon buttons separate the two plates, with a felt wick interposed for lubrication. A pin, riveted to the breaker support plate and passing through an elongated hole in the fixed plate, is provided with a spring tensioning washer and is adjusted by the selection of shims to obtain the requisite pre-load between the plates. A forked plate attached to the spindle of the vacuum control enters the housing through a slot and engages a pin riveted to the breaker support plate. Hence, axial movement of the vacuum control spindle rotates the contact arm about the breaker cam and varies the ignition timing.

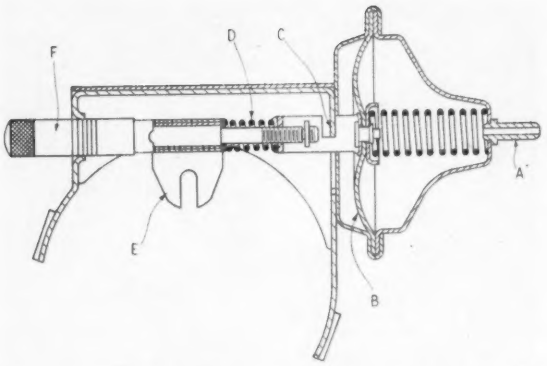
The vacuum control assembly is screwed to the outside of the distributor housing. Projection-welded, mild steel pressings are used for the frame. The two pressings that form the vacuum chamber are crimped together and also hold the flexible diaphragm at its periphery. Induction manifold depression is conveyed to the outer end of the chamber by a pipe. At the centre, the diaphragm is held between two riveted pressings. One forms a seat for the helical reaction spring and the other provides the connection between the diaphragm and the operating spindle. The threaded end of the spindle enters a tapped hole in one pressing, and a tongue on the frame engages in a slot in this pressing to limit the axial movement of the spindle. The opposite end of the spindle projects through a hole in the frame. It has a knurled end that can be turned by hand to adjust the degree of advance to suit the octane rating of the fuel in use. A spring-loaded ratchet provides for 90 deg increments, each of which is equivalent to 1 deg of ignition advance or retard at the crankshaft.

Of particular interest is the method of manufacturing the housing which is in two parts. The bowl, of deep drawing steel, is blanked and drawn on a CP1 Hordern Mason and Edwards press, followed by redrawing, piercing and plunging operations. The other part of the housing, namely the shank, is of mild steel and for subsequent location and oil return is flatted on an Ahcol mill which has a rotary drum and gravity ejection.

General assembly of the Delco-Remy D200 Series four-cylinder distributor

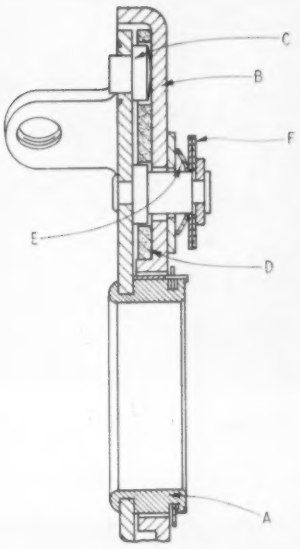
A *drive shaft*, **B** *shank*, **C** *rubber O-ring*, **D** *timing clamp*, **E** *lubrication wick*, **F** *advance and breaker cam assembly*, **G** *breaker assembly*, **H** *rotor*, **J** *contact arm*, **K** *eccentric adjusting screw for contacts*, **L** *locking screw*, **M** *condenser*, **N** *vacuum control*





A *vacuum connection,* **B** *diaphragm,* **C** *limit stop,* **D** *ratchet spring,* **E** *operating fork,* **F** *adjustment spindle*

The vacuum control assembly incorporates a simple hand adjustment



Part section of the contact breaker assembly

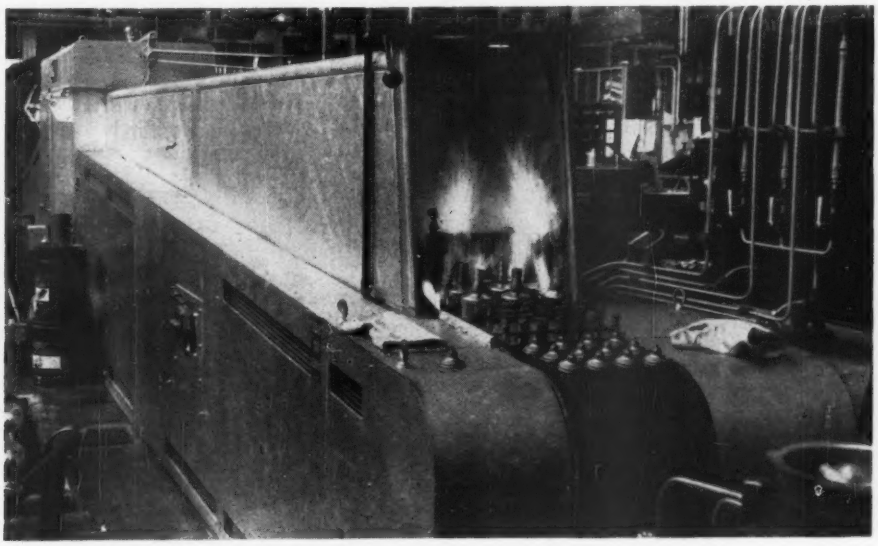
A *bearing,* **B** *breaker support plate,* **C** *nylon button bearing,* **D** *lubrication wick,* **E** *spring tensioning washer,* **F** *shims*

A copper ring is placed at the junction of the shaft and the bowl and the two components are copper-brazed together in a Wild-Barfield continuous brazing furnace. Brazing is followed by broaching the bore on a twin-head broaching machine, further piercing operations on the bowl, and the rolling of the part number on the bowl with a Funditor marking machine.

The high tensile steel drive shaft is centreless ground to a tolerance of $\pm 0{\cdot}00025$ in at the journal surfaces. It has a Rockwell hardness of C20-30, without hardening. The oil return scroll is machined on a Smart and Brown oil grooving machine. It is knurled to receive the weight base, which is fitted over it and metal is swaged into a recess on the shaft, below the knurl, on a 15 ton Mills hydraulic press. The advance weight posts are secured to the base plate by hot upsetting on a Sciaky projection-welding machine. This sub-assembly is then subjected to torque and push-off tests to check the security of the base plate on the shaft.

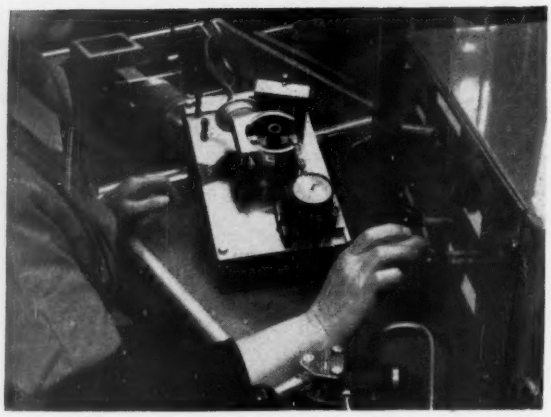
A special-purpose cam grinding machine is used to rough grind the carbon steel contact breaker cam surfaces. After blanking, the centrifugal advance cam plate is shaved to the correct profile on the cam faces on a power press, copper plated and then assembled in the precise relationship to the contact breaker cam on an 8 ton Mills press. The two parts are then copper-brazed together. This is followed by a push-off test. Induction hardening of the surfaces of both cams is carried out on Wild-Barfield high-frequency equipment. There is automatic quenching of the heated surfaces and automatic ejection of the component to the conveyor rails above the plant, which works on a cycle of 15 sec. Finish grinding of the contact breaker cam is done on a special-purpose cam grinding machine to produce a surface finish of 9-10 micro-in. A special checking fixture is then used for 100 per cent inspection for cam synchronism.

Components of the vacuum advance housing are assembled by projection welding and are then passivated zinc plated. The stem for the flexible connection to the engine manifold is copper-brazed to the outer pressing of the vacuum case. The two layers of the fabric, impregnated with oil- and petrol-resistant synthetic rubber are first lightly held between the two pressings that form the vacuum case, and the pressings are then crimped together to secure the diaphragm at its periphery. Final testing of the vacuum advance assembly takes the form of a 100 per cent inspection on an evacuation and calibration test rig.



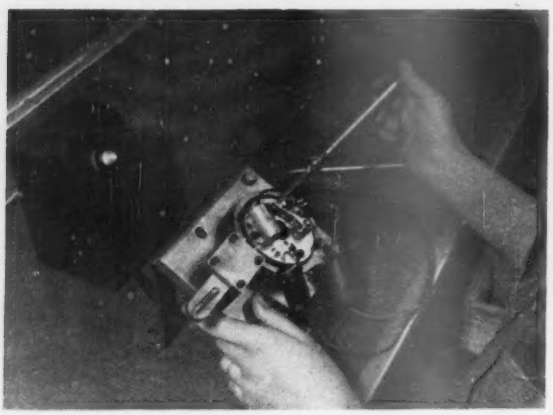
Copper brazing of the housing assembly, cam assembly and diaphragm cover is carried out in a Wild-Barfield continuous furnace

Equipment for setting the rotary drag of the breaker assembly



A vacuum advance assembly under test

Fixture for aligning points and checking spring tension



Electronic equipment for final test

The diaphragm is subjected to a depression measured on manometers and the axial movement produced at the diaphragm spindle is recorded on a dial gauge. Readings are taken for manometer heights of 6 in, 10 in and 20 in of mercury, the final figure being an over-load test. A solenoid around the column and an armature above the mercury is arranged to cut off the vacuum pump at the predetermined test pressure. For a final test, a pressure is applied and sustained for 30 sec.

Hot upsetting is freely employed for the assembly of the various posts and pivots in the contact breaker base assembly. The central brass bearing of this assembly is placed in position and rolled to retain it on a machine having an air-operated toggle with slide. A mandrel press is used to tighten this bearing against the upper and lower plates of the assembly. The operator uses a dial-gauge bearing on the upper plate to obtain the correct amount of "rock" between the two.

This assembly, complete with three nylon thrust buttons and lubricating wick, is next mounted on a test rig. This measures the rotary drag as one plate is rotated, while the other is held. It is important that the drag should be within prescribed limits, since the vacuum advance diaphragm performs this rotation during the operation of the distributor. The upper plate is moved by a solenoid and the current that is required to do this is recorded on a milliammeter. The correct reading corresponds to a thrust of 7-9 oz at the radius of the operating pin. Since the spring tensioning washer that holds the plates together is provided with shims, the operator is able to select the number required to give the correct drag.

Following the assembly of the remaining components, such as the contact breaker arm, the points and the spring, there is a check of the contact breaker spring tension, using a spring balance, and a further test of the rotary drag. Assembly of the distributor takes place on a conveyor. The contact breaker gap is set at a station on the assembly line where the cam dwell angle is checked. The gap is adjusted while the cam is rotated, an arbitrary reading of 0·7 milliamperes being required on the milliammeter. On the same test rig, a megger resistance check of the insulation of the contact breaker is made.

Final inspection is made on special electronic test equipment developed by AC-Delco. This is, in fact, a semi-automatic synchroscope, on which all aspects of distributor performance can be measured. The standard is a distributor with zero advance and all assemblies are checked against it. It incorporates a cathode ray tube, and on the screen are marked the limits of the centrifugal advance curve. The distributor to be tested is mounted on the rig and the shaft is driven at a speed which can be varied. When taken through the operating speed range, movement of the spot on the screen, indicating the degree of advance, is compared with the curves. When the distributor is driven at 500 r.p.m. and connected to a vacuum pump, and the depression is varied, the vacuum advance is read off on a horizontal scale on the screen.

BENDIX ELECTROJECTOR

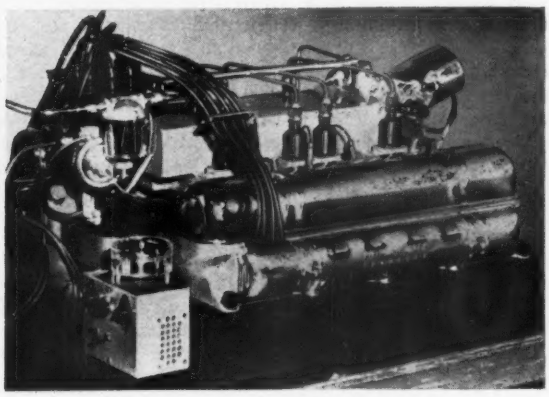
An Electronically-Controlled and Electrically-Actuated Petrol Injection System

A NEW petrol injection system for cars is undergoing development by the Bendix Aviation Corporation, of 205, East 42nd Street, New York 17. One of the noteworthy features of the system is that it does not require a special drive from the engine. Other advantages claimed by the manufacturers are higher volumetric efficiency, better distribution of mixture to the cylinders, improved torque and power output from the engine, better fuel economy, quicker starting from cold and warm-up, a wider range of fuels can be used, compactness of the installation and therefore more free space under the bonnet or a lower bonnet profile, faster and livelier response to the throttle, elimination of vapour locks, the fuel metering to the engine is not affected by the attitude of the vehicle and centripetal accelerations due to cornering, no icing troubles, and the elimination of the manifold hot-spot gives lower induction temperatures and enables higher compression ratios to be used.

One of the questions that are uppermost in the minds of automobile engineers is what are the advantages of the Electrojector arrangement by comparison with other fuel injection systems. According to the manufacturers, the answer to this is that it costs less because it has fewer moving parts, and very close tolerance machining is not required in its manufacture. Also, fuel filtration is not critical. As has already been mentioned, a special drive arrangement does not have to be incorporated in the engine. Since the fuel lines to the injectors are not subjected to high or pulsating pressures, there are no surge or inertia effects. It is relatively easy to adapt current engine designs for the new system and installation on the assembly line should present no difficulties. The Electrojector is quiet in operation and its demands on the electrical system of the vehicle are light. In contrast to most petrol injection systems, the Electrojector arrangement is self-priming and does not ever require bleeding.

Briefly, the aim in the design of the unit has been at meeting the following requirements. The first is, of course, the maintenance of an optimum air:fuel ratio at all times under varying loads and speeds. Enrichment is necessary in starting from cold and the degree of enrichment must be gradually reduced during the warm-up period. During this period, the idling speed has to be faster than normal. In addition, the mixture must be enriched to compensate for exhaust gas dilution of the charge when the engine is idling. At full throttle, enrichment is also required to prevent detonation; and, to avoid flat spots, additional fuel must be supplied during acceleration.

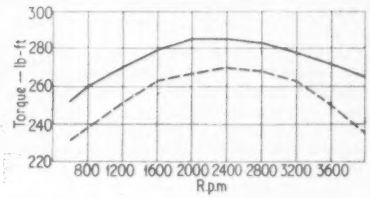
Electrojector installation designed for a V-eight engine



Components

Most of the sensing units of the control are housed in a throttle body, similar to a carburettor throttle body. They include: the fast-idle cam and its thermostat control; an acceleration enrichment control; an inlet manifold pressure sensor and deceleration cut-off; and the idle-range enrichment control. The other components of the system are as follows: a distributor-breaker unit; an electronic modulator; solenoid-actuated injector nozzle for each of the cylinders; and an electronic device for sensing engine temperature. Another sensor, for air intake temperature, and also an altitude compensator are optional extras.

A fuel pump, fuel and air filters, and wiring harness are also essential to the system. Although these can be supplied by other divisions of the Bendix organization, motor manufacturers are free to obtain them from other sources if they wish to do so. A motor-driven, non-metering type electrical pump is offered by The Eclipse Machine Division, of Elmira, New York; conventional fuel and air filters are made by The Skinner Division, of Detroit, Michigan; and a suitable wiring harness can be supplied by The Scintilla



Comparison of the torques obtained with a V-eight engine equipped first with a four-barrel carburetter and then with the Electrojector

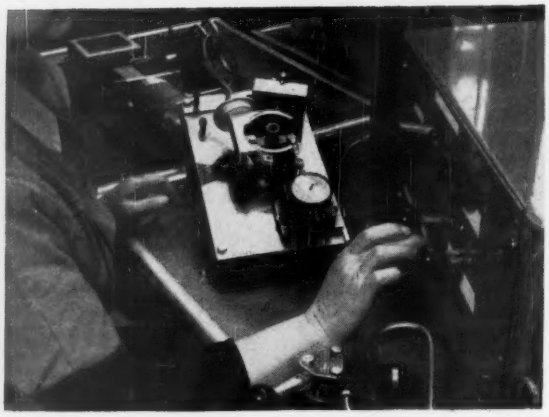
Division, of Sidney, New York, United States of America.

In general, the principle of operation is as follows. Engine requirement signals are electrically transmitted to the electronic modulator, which combines them with timing signals from the distributor-breaker unit and transmits measured pulses to an amplifier. From this amplifier, the output pulses are returned through the distributor-breaker unit to the individual solenoid-actuated injector nozzles. The duration of the nozzle opening is controlled by these pulses, which thus regulate the amount of fuel delivered through the injectors to each cylinder of the engine.

A motor-driven electrical pump maintains a pressure of 20 lb/in² in a common rail system, to which all the injectors are directly connected. This common rail forms part of a single, closed-circuit fuel supply line taken from the tank, through the filter and pump, into the common rail, and then back to the tank. A restriction in the return line helps to maintain constant fuel pressure.

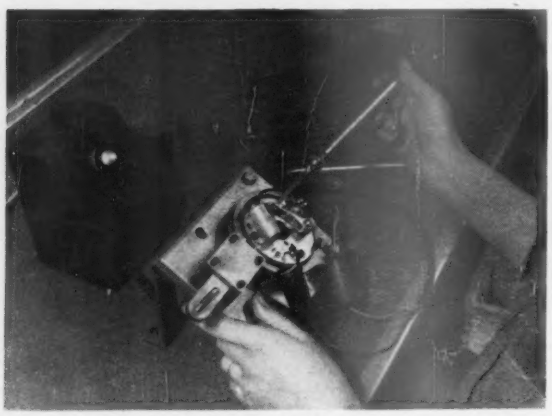
The distributor-breaker unit, which times the injection system, comprises a set of contact breaker points and a distributing commutator. It is interposed between the base

Equipment for setting the rotary drag of the breaker assembly



A vacuum advance assembly under test

Fixture for aligning points and checking spring tension



Electronic equipment for final test

The diaphragm is subjected to a depression measured on manometers and the axial movement produced at the diaphragm spindle is recorded on a dial gauge. Readings are taken for manometer heights of 6 in, 10 in and 20 in of mercury, the final figure being an over-load test. A solenoid around the column and an armature above the mercury is arranged to cut off the vacuum pump at the predetermined test pressure. For a final test, a pressure is applied and sustained for 30 sec.

Hot upsetting is freely employed for the assembly of the various posts and pivots in the contact breaker base assembly. The central brass bearing of this assembly is placed in position and rolled to retain it on a machine having an air-operated toggle with slide. A mandrel press is used to tighten this bearing against the upper and lower plates of the assembly. The operator uses a dial-gauge bearing on the upper plate to obtain the correct amount of "rock" between the two.

This assembly, complete with three nylon thrust buttons and lubricating wick, is next mounted on a test rig. This measures the rotary drag as one plate is rotated, while the other is held. It is important that the drag should be within prescribed limits, since the vacuum advance diaphragm performs this rotation during the operation of the distributor. The upper plate is moved by a solenoid and the current that is required to do this is recorded on a milliammeter. The correct reading corresponds to a thrust of 7-9 oz at the radius of the operating pin. Since the spring tensioning washer that holds the plates together is provided with shims, the operator is able to select the number required to give the correct drag.

Following the assembly of the remaining components, such as the contact breaker arm, the points and the spring, there is a check of the contact breaker spring tension, using a spring balance, and a further test of the rotary drag. Assembly of the distributor takes place on a conveyor. The contact breaker gap is set at a station on the assembly line where the cam dwell angle is checked. The gap is adjusted while the cam is rotated, an arbitrary reading of 0·7 milliamperes being required on the milliammeter. On the same test rig, a megger resistance check of the insulation of the contact breaker is made.

Final inspection is made on special electronic test equipment developed by AC-Delco. This is, in fact, a semi-automatic synchroscope, on which all aspects of distributor performance can be measured. The standard is a distributor with zero advance and all assemblies are checked against it. It incorporates a cathode ray tube, and on the screen are marked the limits of the centrifugal advance curve. The distributor to be tested is mounted on the rig and the shaft is driven at a speed which can be varied. When taken through the operating speed range, movement of the spot on the screen, indicating the degree of advance, is compared with the curves. When the distributor is driven at 500 r.p.m. and connected to a vacuum pump, and the depression is varied, the vacuum advance is read off on a horizontal scale on the screen.

BENDIX ELECTROJECTOR

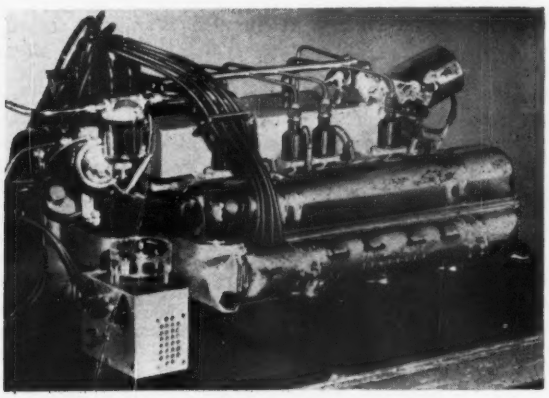
An Electronically-Controlled and Electrically-Actuated Petrol Injection System

A NEW petrol injection system for cars is undergoing development by the Bendix Aviation Corporation, of 205, East 42nd Street, New York 17. One of the noteworthy features of the system is that it does not require a special drive from the engine. Other advantages claimed by the manufacturers are higher volumetric efficiency, better distribution of mixture to the cylinders, improved torque and power output from the engine, better fuel economy, quicker starting from cold and warm-up, a wider range of fuels can be used, compactness of the installation and therefore more free space under the bonnet or a lower bonnet profile, faster and livelier response to the throttle, elimination of vapour locks, the fuel metering to the engine is not affected by the attitude of the vehicle and centripetal accelerations due to cornering, no icing troubles, and the elimination of the manifold hot-spot gives lower induction temperatures and enables higher compression ratios to be used.

One of the questions that are uppermost in the minds of automobile engineers is what are the advantages of the Electrojector arrangement by comparison with other fuel injection systems. According to the manufacturers, the answer to this is that it costs less because it has fewer moving parts, and very close tolerance machining is not required in its manufacture. Also, fuel filtration is not critical. As has already been mentioned, a special drive arrangement does not have to be incorporated in the engine. Since the fuel lines to the injectors are not subjected to high or pulsating pressures, there are no surge or inertia effects. It is relatively easy to adapt current engine designs for the new system and installation on the assembly line should present no difficulties. The Electrojector is quiet in operation and its demands on the electrical system of the vehicle are light. In contrast to most petrol injection systems, the Electrojector arrangement is self-priming and does not ever require bleeding.

Briefly, the aim in the design of the unit has been at meeting the following requirements. The first is, of course, the maintenance of an optimum air:fuel ratio at all times under varying loads and speeds. Enrichment is necessary in starting from cold and the degree of enrichment must be gradually reduced during the warm-up period. During this period, the idling speed has to be faster than normal. In addition, the mixture must be enriched to compensate for exhaust gas dilution of the charge when the engine is idling. At full throttle, enrichment is also required to prevent detonation; and, to avoid flat spots, additional fuel must be supplied during acceleration.

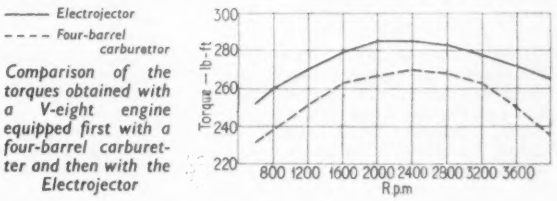
Electrojector installation designed for a V-eight engine



Components

Most of the sensing units of the control are housed in a throttle body, similar to a carburettor throttle body. They include: the fast-idle cam and its thermostat control; an acceleration enrichment control; an inlet manifold pressure sensor and deceleration cut-off; and the idle-range enrichment control. The other components of the system are as follows: a distributor-breaker unit; an electronic modulator; solenoid-actuated injector nozzle for each of the cylinders; and an electronic device for sensing engine temperature. Another sensor, for air intake temperature, and also an altitude compensator are optional extras.

A fuel pump, fuel and air filters, and wiring harness are also essential to the system. Although these can be supplied by other divisions of the Bendix organization, motor manufacturers are free to obtain them from other sources if they wish to do so. A motor-driven, non-metering type electrical pump is offered by The Eclipse Machine Division, of Elmira, New York; conventional fuel and air filters are made by The Skinner Division, of Detroit, Michigan; and a suitable wiring harness can be supplied by The Scintilla Division, of Sidney, New York, United States of America.



Comparison of the torques obtained with a V-eight engine equipped first with a four-barrel carburetter and then with the Electrojector

In general, the principle of operation is as follows. Engine requirement signals are electrically transmitted to the electronic modulator, which combines them with timing signals from the distributor-breaker unit and transmits measured pulses to an amplifier. From this amplifier, the output pulses are returned through the distributor-breaker unit to the individual solenoid-actuated injector nozzles. The duration of the nozzle opening is controlled by these pulses, which thus regulate the amount of fuel delivered through the injectors to each cylinder of the engine.

A motor-driven electrical pump maintains a pressure of 20 lb/in² in a common rail system, to which all the injectors are directly connected. This common rail forms part of a single, closed-circuit fuel supply line taken from the tank, through the filter and pump, into the common rail, and then back to the tank. A restriction in the return line helps to maintain constant fuel pressure.

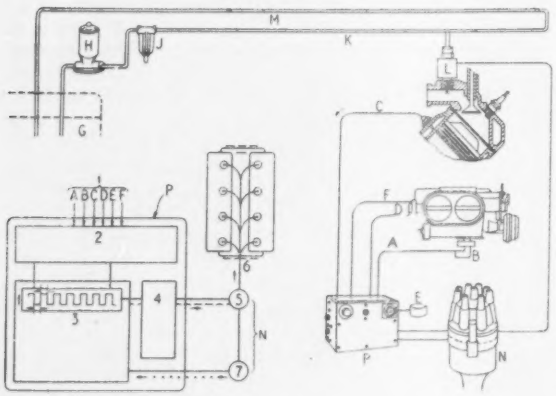
The distributor-breaker unit, which times the injection system, comprises a set of contact breaker points and a distributing commutator. It is interposed between the base

of the ignition distributor assembly and its cap and rotor, the cam being common to both units. The addition of the distributor-breaker unit increases the height of the ignition distributor assembly by about 1 in.

Fuel Metering

Fuel metering is controlled primarily by the induction manifold pressure, or vacuum. The starting and warm-up enrichment demand is signalled by an electronic sensor, which measures engine temperature. For fast idle during warm-up, a conventional thermostat-controlled cam arrangement, similar to that employed with a carburettor, is employed. The idle-range enrichment signal is given by an electric switch actuated by the throttle. Enrichment for acceleration is signalled by a throttle-actuated mechanism or by a rapid change in manifold pressure. The duration of the acceleration enrichment is determined by the electronic modulator in accordance with engine requirements.

Basically, the inlet manifold pressure sensing unit consists



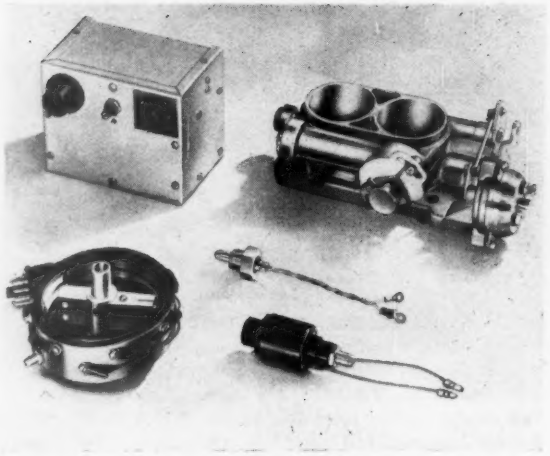
A *intake manifold pressure signal;* **B** *deceleration cut-off;* **C** *starting and warm-up enrichment signal;* **D** *idle enrichment signal;* **E** *automatic altitude compensator;* **F** *acceleration enrichment signal;* **G** *fuel tank;* **H** *fuel pump;* **J** *fuel filter;* **K** *supply, at 20 lb/in²;* **L** *injector nozzle;* **M** *fuel return;* **N** *distributor-breaker unit;* **P** *electronic modulator*

Electrojector system and, on the left, the electronic modulator circuit. The signals 1 are fed into the control circuit 2, which integrates them and modulates the action of the multi-vibrator 3, to control the duration of the pulses—the multi-vibrator circuit is triggered by spike signals from the points 7 in the distributor-breaker unit N. Next, the pulse current is amplified in the unit 4, and passed though the distributor 5, in the distributor-breaker N, to the injectors on the engine manifold 6

of a spring-loaded piston in a tube. One end of the tube is connected to the manifold and the other is open to atmosphere. When the manifold pressure drops relative to atmospheric pressure, the piston is drawn along the tube, against the resistance of the spring. Thus, the position of the piston is determined by the depression in the manifold. The piston is connected to a potentiometer, which sends a signal to the electronic modulator. When the piston is in the extreme position, during deceleration with the throttle closed, the fuel supply is automatically cut off altogether.

If automatic compensation for altitude is required, it is effected by an aneroid device. The signal from this control is transmitted to the electronic modulator, which maintains a constant air:fuel ratio, regardless of altitude. An electronic sensor is employed if ambient air temperature compensation is required.

The electronic modulator contains a multi-vibrator circuit and an amplifier. All the sensing signals and the timing signal are integrated in the multi-vibrator circuit, to develop a pulse signal. This latter signal opens the injectors for the precise period of time necessary for the delivery of



Components of the Electrojector system. They are: top left, electronic modulator; top right, throttle body; bottom left, distributor-breaker unit; bottom right, injector; and centre, thermistor to sense temperature

the exact amount of fuel to suit the engine requirements at that instant. The amplifier increases the current of the output signal to a level high enough to operate the solenoid valve in the injector.

To all practical intents the entire action is instantaneous. Thus, the delivery of metered fuel is precisely synchronized with the engine demand. This gives optimum performance, power and economy. With the Electrojector system there is neither mechanical nor hydraulic lag. Transistors, unlike valves, have no filament, and therefore do not have to be warmed up before they can operate efficiently. Moreover, they have an almost unlimited life expectancy and their demand for current is extremely small.

Each fuel injector consists of a solenoid coil in a case. The core of the coil contains a valve on a plunger backed by a spring. This spring keeps the valve on its seat until the solenoid lifts it. The nozzle orifice is relatively large and therefore does not suffer from the fouling problems encountered with some other fuel injection systems.

It is stated by the manufacturers that tests have indicated that a horse power increase of about 10 per cent can be obtained by substituting the Electrojector for a conventional four-barrel carburettor. Further improvements could be obtained by designing the manifold specifically for the Electrojector system. An even more important feature is the improvement obtainable in respect of torque characteristics. With the Electrojector installation, maximum torque can be obtained at 1,200 r.p.m., whereas with a typical carburettor installation on the same engine, it is obtained at 2,400 r.p.m. Furthermore, an overall increase in torque at all speeds is obtained. The uniform distribution of mixture to the cylinders enables weaker mixtures to be employed, since there is no need to supply an over-rich mixture to some of the cylinders in order to avoid starving others. Further improvements in economy are obtained because of the rapidity with which an engine equipped with the Electrojector system warms up, by comparison with one having a conventional carburettor arrangement.

The product designs, laboratory tests and road tests are now complete in so far that the next stage is the adaptation of the system to individual engine requirements. Vehicle manufacturers are at present testing the system in their laboratories and proving grounds. In view of the relative complexity of the carburettors employed on some of the American V-eight engines it seems that petrol injection systems might prove to be an attractive alternative.

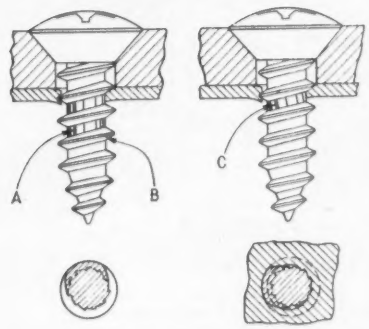
CURRENT PATENTS

A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Self-tapping, self-locking screw

By this invention the widely used self-tapping screw is formed with a ratchet-like configuration on a portion of its shank to provide a self-locking feature. The normal thread of such a screw is of a relatively coarse pitch and the turns of the thread are separated by a cylindrical root portion. It is this root portion that is deformed, for one or more turns, to provide the ratchet-like locking teeth. The operation is effected simultaneously with the formation of the thread, by means of suitably modified thread-rolling dies.

Two types of locking teeth are illustrated Both are similar in profile, with a substantially radial short face and a substantially



No. 757763

circumferential long face. While those at A are parallel to the screw axis, those at C are perpendicular to the thread B, or may be inclined at a greater angle, so that on rotation of the screw in a direction to loosen, they tend to exert a wedging or camming action on the material penetrated. Thus their resistance to the accidental loosening of the screw is enhanced. *Patent No.* 757763. *American Screw Co. (U.S.A.).*

Servo-assisted brake system

A disc brake on the vehicle transmission line operates as a servomotor and applies fluid pressure to the wheel brakes. It is intended particularly, but not exclusively, for use in conjunction with disc-type wheel brakes. The disc A is secured to the vehicle propeller shaft and the torque plate B carrying the brake caliper is mounted on bearings on the shaft and permitted to make a predetermined angular movement in each direction from its mid-position between a pair of circumferentially spaced stops (not shown). This servo-brake is actuated by a conventional, pedal-operated, hydraulic master cylinder C.

The brake caliper, at its outer periphery, is pivotally linked to the shorter arm of a rocking lever D, the other arm being linked to the piston rod of the servo-cylinder E which operates the four wheel brakes. Adjustment may be provided at the pivotal point of lever D to vary the mechanical advantage of the lever. It will be noted that the servo-brake works equally well whether the vehicle is travelling forwards or in reverse.

On release of the control pedal the braking load on the servo-brake is removed and the spring in the servo-cylinder returns the servo-piston and releases the wheel brakes. If desired, springs F may be fitted to centralize the torque plate B in the inoperative position. *Patent No.* 757739. *Dunlop Rubber Co. Ltd.*

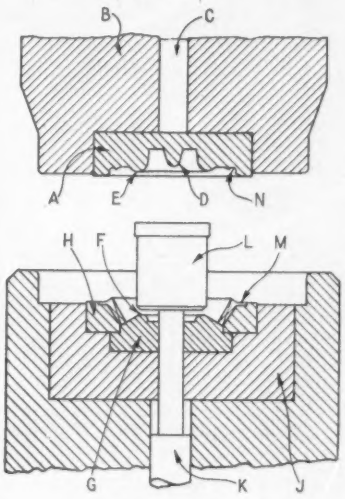
Precision forging of gear wheels

By this method, it is claimed, steel bevel and spur gears can be formed with such accuracy that they can be used in precision assemblies without subsequent machining or with only the lapping or polishing of the teeth. Major importance is attached to performing the pressing operation in the shortest possible time; in a fraction of a second. At the moment of pressing the blank should have a temperature near to the upper limit of forging temperatures customarily used, to ensure the filling of all cavities in the matrix.

Illustrated is the set-up for forging bevel pinions for a differential gear. The punch A is shrunk in the press ram B which has one or more bores C to enable the punch to be driven out and also, if desired, to provide passage for cooling agents. An axially located protuberance D does not project so far as the concentric annular rib E which is opposite to a corresponding rib F on the die G. As punch and die approach when the press strokes, these ribs form an annular nozzle through which the metal of the blank flows radially outwards at an enhanced velocity to fill the interstices in the matrix H for the teeth.

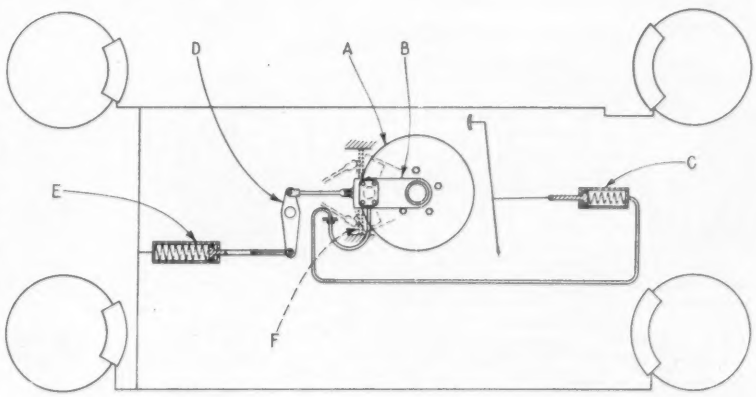
The die and the matrix are pressed or shrunk in a support block J inserted in the anvil of the press, and die, support, and anvil have a coaxial bore to accommodate an ejector K. Since it is impractical to dimension the blank L so that there is no surplus metal, a shallow recess M is formed in the matrix and another recess N is provided in the punch to furnish a means of escape for such surplus. Machined all over to accurate dimensions and inspected for cracks, the blank is substantially cylindrical in shape with an enlarged head and a slightly tapered foot.

Initially the punch, die, and matrix are raised to a temperature of 400 deg C and sprayed with castor oil. Then the blank, heated to a temperature of 1,080 deg C, is placed on the end of the ejector just clear of the die and forged by a very rapid blow of the punch. Immediately after the



No. 754495

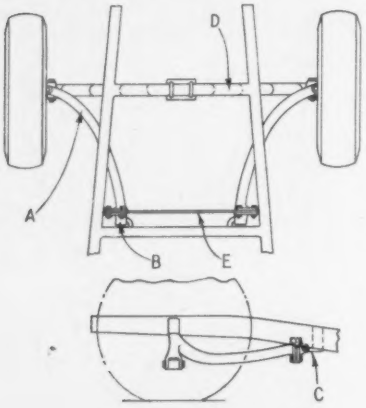
pressing operation the punch is raised, and the forged gear is lifted clear by the ejector. The gear is subsequently cooled slowly in a bed of sand. The temperature of the matrix may be raised to about 665 deg C and immediately the forging is ejected it is cooled to 400 deg C by blowing with cold compressed air. *Patent No.* 754495. *Bayerisches Leichtmetallwerk A.G. (Germany).*



No. 757739

Independent front-wheel suspension

Simplicity of construction and a reduced number of component parts are the objects of this independent front suspension which incorporates an anti-rolling device. In the form illustrated it has only four pivots. Each wheel is mounted to swivel on the forward end of a longitudinally arranged arm A which at the rear is flanged and bolted to a short extension piece B pivoted by means of a rubber bushing to a bracket C on a frame cross member. To the forward ends are pivoted, not shackled, the ends of a simple transverse spring D clamped centrally to the underside of the front cross member. Rubber bushes are provided at the spring eyes.



No. 755708

Clamped between the flanges of parts A and B is a stabilizing spring E consisting of one or more leaves lying in a vertical plane. This spring acts in torsion as an anti-roll bar, in the vertical plane it serves as a beam tending to keep the wheels upright, and in the horizontal plane it bends slightly to accommodate lateral movement of the arms under the influence of the main load-carrying spring D.

The specification covers modifications of the system by the substitution of transverse links and separate helical, torsion, pneumatic, or rubber springs for the single transverse spring D, and also the use of the system for the independent suspension of rear wheels. *Patent No.* 755708. *V. Heron* (*Canada*).

Polytetrafluoroethylene-coated pistons and rings

To reduce the sliding friction of the reciprocating parts of high-speed internal combustion engines, the piston and the piston rings are coated with a thin, hard and tough coating of polytetrafluoroethylene. Such a coating can be applied by spraying or dipping, functions equally well on cast iron, light alloy or other metals, is thermally stable and, being relatively chemically inert, will not adversely affect either lubricating oil or metallic surfaces.

Rust, organic coatings, or dirt are removed from the parts by sandblasting followed by washing in a volatile solvent. If the p.t.f.e. has been stored for some time, it should be passed through a cloth filter to remove any particles of coagulum. It is applied in the form of a low-viscosity dispersion in water, preferably at room temperature as too rapid evaporation of the water will result in an unequal distribution and a consequent unequal coating thickness. After drying out, the coated part is baked at a temperature of at least 750 deg F until the p.t.f.e. is sintered. An exceptionally hard coating is produced if the part, after sintering, is immediately immersed in water. This process is repeated several times to build up the coating to the required thickness. Too thick a single layer will result in a rough, irregular surface, designated as "orange peel."

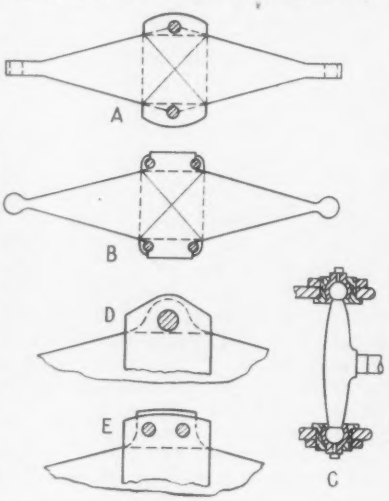
To obtain satisfactory adhesion it is usually advisable to apply an initial layer of a p.t.f.e. priming, such as Dupont Teflon Primer 850-201. Dupont Clear Finish 852-201 can be used for the finish coating. Satisfactory results are obtained if the average total thickness of the plurality of layers is from 0·001 in to 0·005 in. Preferably, the coating thickness should be between 0·0015 in and 0·0025 in and the priming layer, if used, should be from 0·0002 in to 0·0005 in thick.

Tests showed that p.t.f.e.-coated rings can be used over greatly extended periods of time under normal operating conditions without detriment to the coatings. A set of coated piston rings (number unspecified) showed a reduction of 8 per cent in engine friction as compared with a set of conventional, chrome-plated rings in the same engine under similar conditions.

Pistons coated with p.t.f.e. by the same methods were tested and the coating was found intact after 10,000 miles operation under normal conditions. Engine friction was found to be 4 per cent less than with uncoated pistons in the same engine under similar conditions. It was also proved advantageous to coat the piston crown. This reduced the amount of heat conducted from the combustion space to the piston and, furthermore, served to reduce the amount of carbonaceous matter deposited on the crown by the combustion of the air-fuel mixture. *Patent No.* 754870. *General Motors Corp.* (*U.S.A.*).

Fuel injection pump coupling

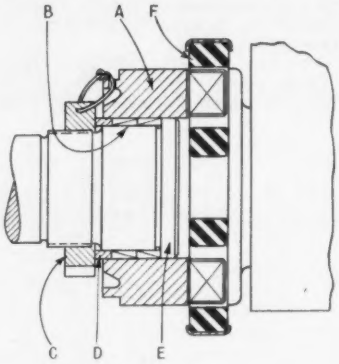
In a conventional construction, one flange of the coupling for a fuel injection pump is divided and pressure-locked by tightening screws to furnish a means of adjusting the timing of the injection. Should the screws be inadequately tightened, or become loose in operation, relative rotation of the two parts of the flange may occur until the permitted range is taken up and a positive drive is established at an incorrect timing. In such circumstances the engine may suffer from overheating, leading to serious damage, and the invention claims to obviate this contingency.



No. 754485

Instead of keying a divided flange to the drive shaft a solid flange A is pressure-locked to the shaft by means of annular tightening rings B. These consist of endless rings arranged in pairs and having complementary conical contacting surfaces which produce a radial locking pressure when they are pressed together axially.

After setting the injection timing of the pump, rings B are pressed by a nut C through the agency of a spacing bush D against a shoulder E on the end of the shaft. When drawn up the nut C is secured against loosening by a safety wire. The arrangement permits a longitudinal adjustment of the flange on the shaft, and in the event of loosening occurring there is no danger of a positive drive.



No. 756836

Coupling elements engage by means of dogs in the usual manner, and a resilient disc F is provided as a shock absorber between the two flanges. *Patent No.* 756836. *Fried Krupp Motoren-und Kraftwagenfabriken G.m.b.H.* (*Germany*).

Transverse leaf spring suspension

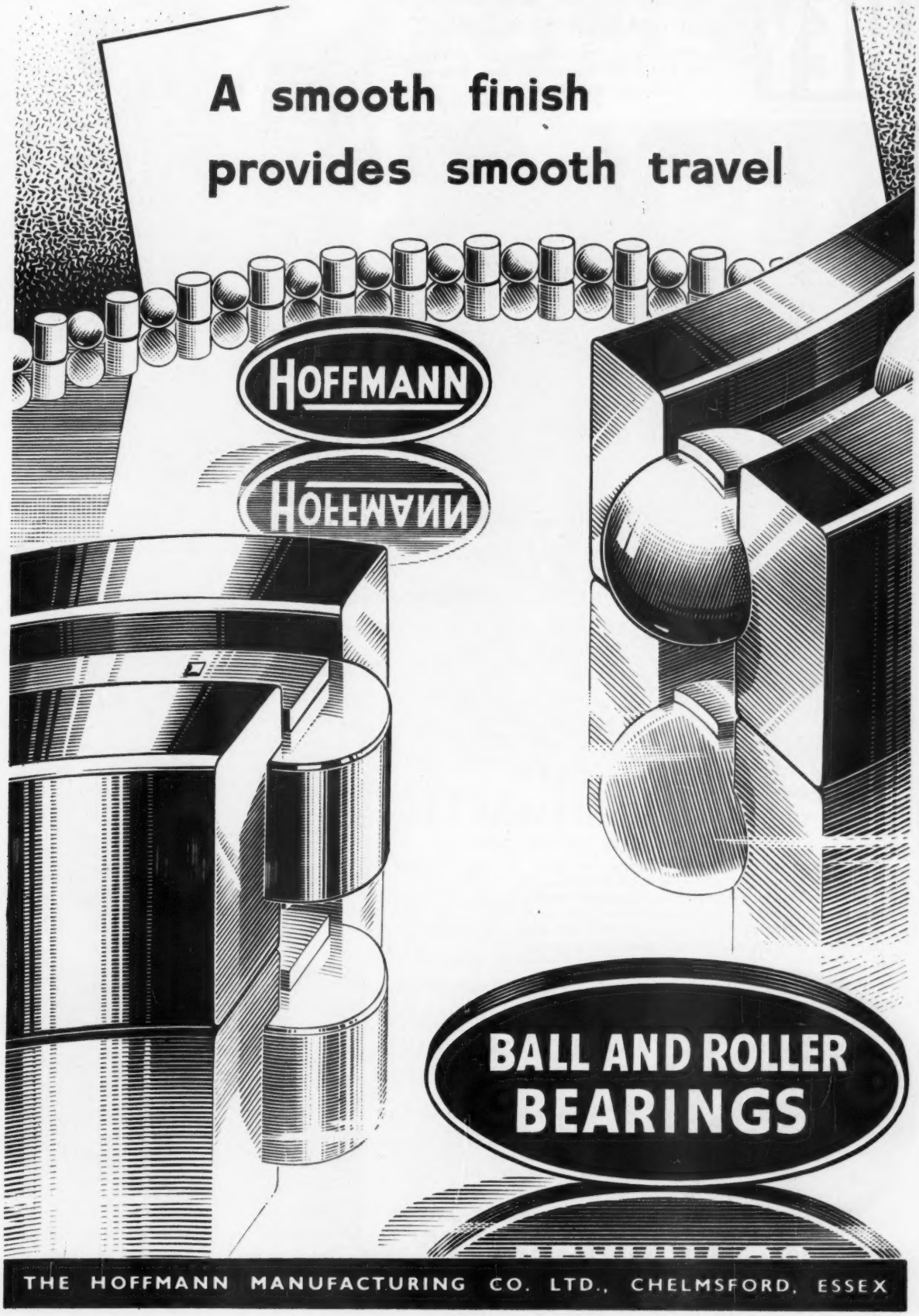
A simple suspension system comprising upper and lower rhomboidal-shaped, single-leaf springs mounted transversely on the vehicle was described in an earlier Patent No. 746729.* The present specification deals with the attachment and postive location of such springs which constitute the sole guiding means for the road wheels. From its ends the spring widens to a central, quadrilateral clamping area and to avoid weakening or stress-raising holes or grooves the locating means are arranged outside this area.

Several methods of location are illustrated. At A, shown with the clamp plate in position, the spring at its central, widest part is provided with part-circular notches to engage the two clamping bolts. The spring ends are formed as eyes to receive pivot pins for the wheel carriers.

The clamping plate is omitted at B to show the notched arrangement for a four-bolt fixing. The ends of this spring are bored to accommodate ball cups for a spherical-ended wheel carrier, as at C.

In alternative two-bolt and four-bolt attachments the springs are provided with central ears that are drilled and threaded over the clamping bolts, as at D and E respectively. *Patent No.* 754485. *Daimler-Benz A. G.* (*Germany*).

*"*Automobile Engineer*", October 1956.

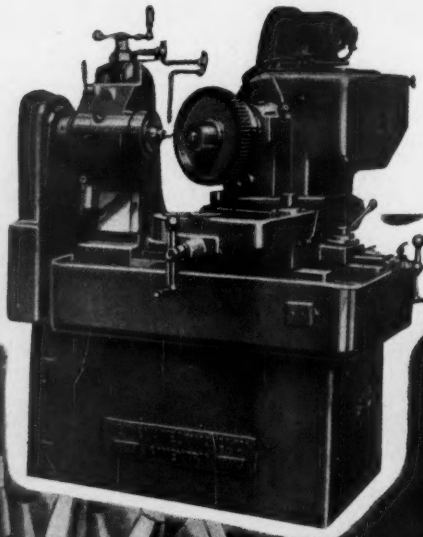


THE HOFFMANN MANUFACTURING CO. LTD., CHELMSFORD, ESSEX

HEY

GEAR TOOTH ROUNDING and CHAMFERING MACHINES

Automatic operation, High Production Rates on External and Internal Gears, Starter Rings, etc.



Used extensively by all leading gear specialists, automobile, aircraft, machine tool manufacturers, etc. Two models available for work up to 20in. and 10in. diameter. Illustrated data on request.

HEY ENGINEERING CO. LTD.
COVENTRY 'PHONE: COVENTRY 88641

We also manufacture Rotary Cam and Profile Milling Machines, Short Thread Milling Machines, Multiple Drilling Heads and Machines, Tapping Machines, End Facing and Centring Machines, Special Machine Tools for High Production.

Rainbow

RUBERY OWEN

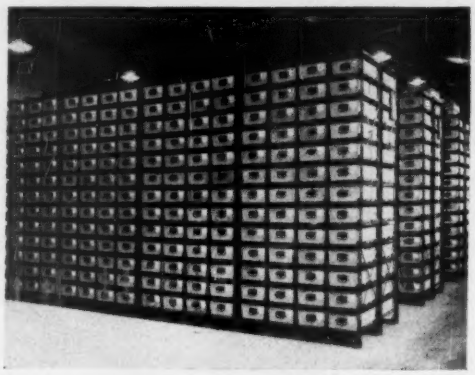
"get to work"-pans

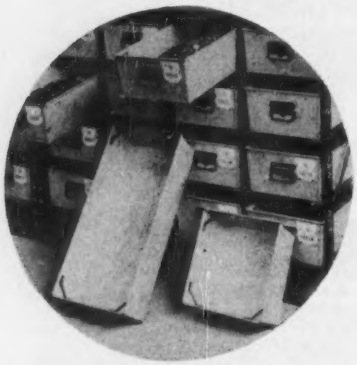
FOR

TILLING-STEVENS LTD.

A ROOTES GROUP COMPANY

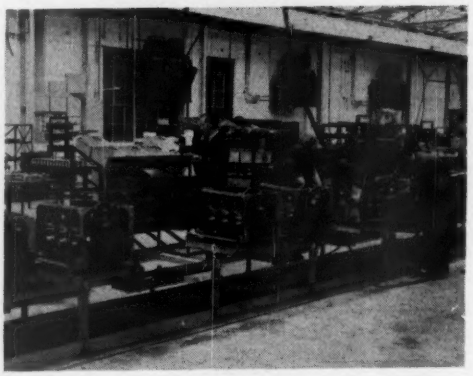
This famous automobile engineering company is one of many concerns who make great use of R.O. Workpans and Racks.
Nuts, bolts, and other small components are contained in various sizes of galvanised pans which are housed in double-sided racks in the stores area. The pans are transported for use on the engine assembly line where they are also housed in smaller inclined racks.





Pans used in the above installation are galvanised finish with wire reinforced corners. In 3 sizes: 12″×12″, 18″×12″, 24″×12″,—6″ deep. Will nest freely. Can be transported in unit loads. Suitable static racks and rack pallets also available.

✳ Rubery Owen offer various designs of the pans for work storage and movement by truck or conveyor, together with suitable racks and rack pallets. Full details on request.



BUSINESS EFFICIENCY EXHIBITION
STAND, Nos. 53/68

RUBERY OWEN & CO. LTD., Industrial Storage Equipment Division
WHITEGATE FACTORY, WREXHAM, N. Wales. Telephone: Wrexham 3566-8

Member of the Owen Organisation

"ILOCUT"

CUTTING OILS

—used by NORTON MOTORS Ltd

On this lathe, "Ilocut" is being used to bore and face light alloy die cast front hub shells.

INDUSTRIAL
WAKEFIELD-DICK
LUBRICANTS

And users not only of our range of "Ilocut" Neat oils—but "Dixol" Soluble oils, too. In fact, the famous Norton company uses Wakefield-Dick production oils exclusively. Why do so many leading engineering companies specify our production oils? Basically, because their consistently high quality helps to get better results. And, hardly less important, because our highly skilled production oils engineers are always able to help over unfamiliar hurdles. In short, "know-how" and "service".

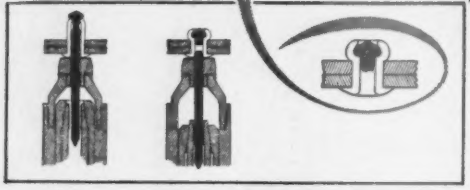
WAKEFIELD-DICK INDUSTRIAL OILS LTD · 67 GROSVENOR STREET · LONDON · W.1

For quicker and more economical assembly

In constant use where speed, economy and simplicity are essential, the "Pop" Riveting System is solving assembly problems in an ever-increasing range of industries.

Almost limitless in its applications, it requires only one operation by one operator, working from one side of the material only, to set or clench the rivet, thereby enabling rivets to be set in positions inaccessible by other methods.

Our technical staff will be pleased to co-operate in solving your assembly problems.



The illustration above shows "Pop" Rivets being used attaching springs for holding moulding finishers—just one of the many applications in the motor industry.

TUCKER POP RIVETS

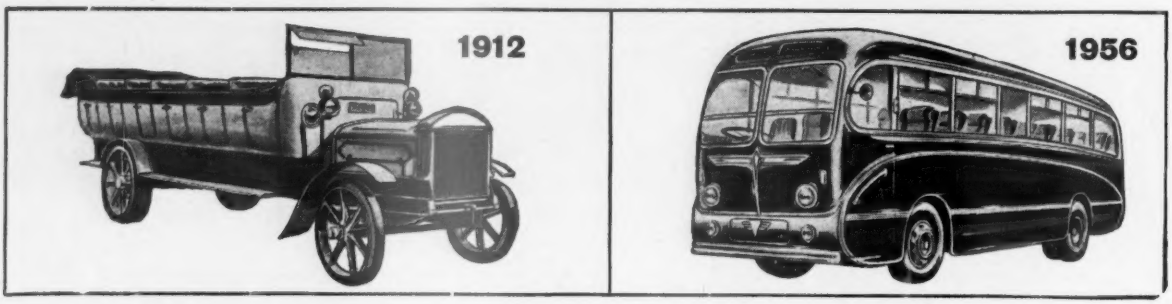
Geo. **TUCKER EYELET** Co. Ltd.

Walsall Road . . . **BIRMINGHAM 22**

Telephone: BIRchfields 5024 (7 lines) Telegrams: EYELETS, BIRMINGHAM

Consultants: **AIRCRAFT MATERIALS LTD.** Midland Road, London, N.W.1

"POP" is a regd. Trade Mark of Geo. Tucker Eyelet Co. Ltd.



50-year-old coach company praises economy of AL-FIN armoured ring groove long life pistons

From solid-tyred chain-drive 'char-a-bancs' to modern 41-seater diesel luxury coaches

The modern fleet operated by Samuel Ledgard — oldest private coach company in the West Riding of Yorkshire — comprises 150 vehicles covering 4,000,000 miles a year. This wealth of experience gives added weight to their endorsement of the economy of Al-Fin Pistons. They say:

"The first sets of Al-Fin pistons were examined at 110,000 miles, when new rings were fitted. Subsequently, these pistons continued to give normal service over arduous routes up to 190,000 miles, when ring groove wear was only .005/.007". The cylinder bores required no attention either, which spoke volumes for the functioning of the piston rings which included a top Welcrom ring. Economies in time and money, therefore, over previous practice are very obvious. *We do not hesitate to recommend the fitting of Wellworthy Al-Fin pistons every time.*

AL-FIN pistons more than pay for themselves in the first year

The armoured ring groove insert gives the Al-Fin piston at least 100% more life than normal types. This double mileage saves the cost of one overhaul *and* another set of pistons. No wonder large fleet owners say:

AL-FIN is the best investment yet!

WELLWORTHY

ARMOURED RING GROOVE AL-FIN LONG LIFE PISTONS

the choice of the expert

Write for leaflet A.8/6 to: WELLWORTHY LTD · LYMINGTON · HANTS

Take us fishing, Dad!

...we can't damage the car upholstery

It's made with

GEON PVC

Yesterday—when boy met dog—seat covers met disaster. There was always a threat from old bones, scratches, mud, grease or just plain high-spirited demolition.

Today—you can specify leathercloth made with Geon PVC. As more and more manufacturers are discovering, PVC leathercloth completely satisfies their requirements and increases customer satisfaction.

Please write for descriptive booklet No. 116 *free on request.*

Everflex PVC leathercloth by Bernard Wardle used as car upholstery material at the Coventry factory of Carbodies Ltd.

LEATHERCLOTH MADE WITH GEON PVC

Will not scratch

Sponges clean in a stroke

Resists heavy wear

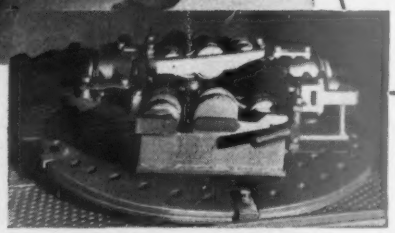
Is impervious to stains

BRITISH GEON LIMITED

Geon
Polyvinyl Materials

Sales and Technical Service

DEVONSHIRE HOUSE PICCADILLY LONDON W1 TELEPHONE MAYFAIR 8867



TILLING-STEVENS

PROLONG FATIGUE LIFE
BY SHOT PEENING

Here is a less publicised but most important application of the Wheelabrator Airless Shot system. The operation is Shot Peening; the component, the rocker arm of a 3 cylinder 2 stroke diesel engine; and the process: treating the inner arches so as to strengthen the outer fibres against direct stresses. Messrs. Tilling-Stevens Ltd., of Maidstone, extend the fatigue life of these highly stressed components by submitting them to 3 minutes under a blast of S.320 cast steel ball shot. Much research has proved the superiority of WHEELABRATOR cast steel ball shot for many such processes and adequate stocks are carried to offer immediate delivery of all grades.

TILGHMAN'S

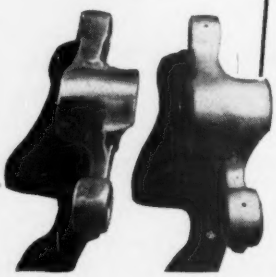
AIRLESS

WHEELABRATORS

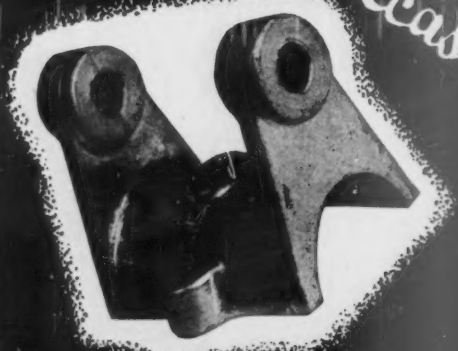
★ *ALSO WHEELABRATOR STEEL SHOT*
FOR IMMEDIATE DELIVERY IN ALL GRADES

TILGHMAN'S LIMITED
A Member of the Staveley Group of Companies.
BROADHEATH · ALTRINCHAM
CHESHIRE
LONDON OFFICE: 1 CHESTER STREET, S.W.1

AGENTS:
MIDLANDS: R. J. Richardson & Sons Ltd., Commercial St., Birmingham, 1
SCOTLAND: Balbardie Limited, 227 Bath Street, Glasgow, C.2.
110 Hanover Street, Edinburgh, 2.
NORTHERN IRELAND: W. E. Stewart, 16 Sussex Place, Belfast.



FOR Diecastings as strong as steel

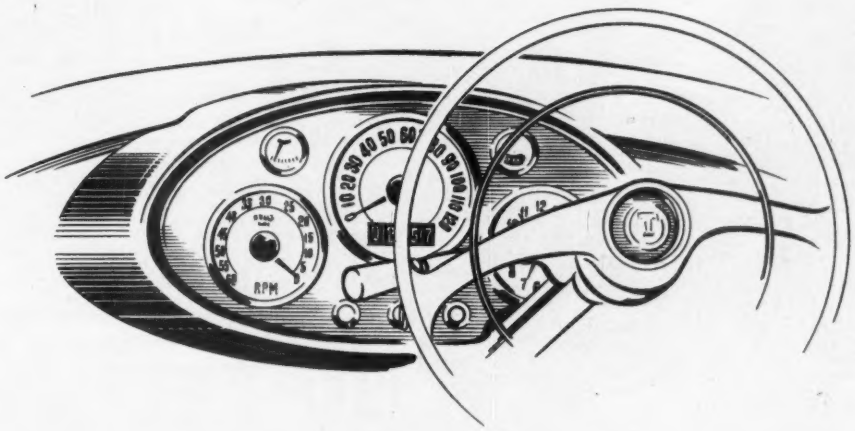


ALUMINIUM BRONZE CO. LTD.

Wallows Lane · Walsall · Staffs.

Telephone WALSALL 21083
Telegrams "ABCO WALSALL"

What's behind all this?



TECHNOGRAPH

World Patented

PRINTED CIRCUITS

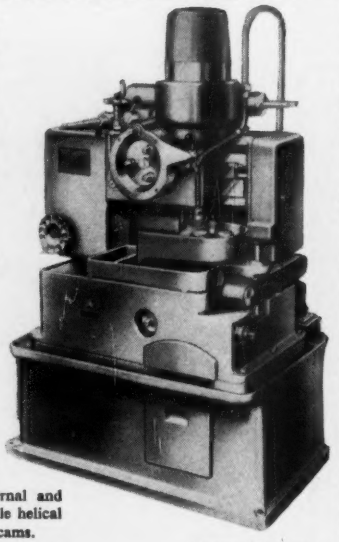
Wherever a reliable, economic wiring circuit is required consult

TECHNOGRAPH ELECTRONIC PRODUCTS LTD

32 SHAFTESBURY AVENUE, LONDON, W.1

TELEPHONE: GERRARD 4532/3

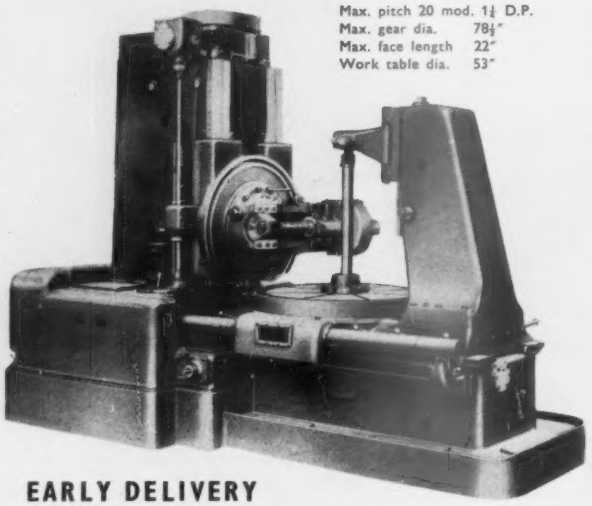
VOLMAN
Gear Hobbers & Gear Shapers



GEAR HOBBING MACHINE OF16

The heavy duty Volman Gear Hobbers are unexcelled for high rate production of precision spur, helical and worm gears. Tangential head available for cutting worm wheels.

Max. pitch 20 mod. 1¼ D.P.
Max. gear dia. 78¼"
Max. face length 22"
Work table dia. 53"



EARLY DELIVERY

★ COMPETITIVE PRICES

OTHER SIZES AVAILABLE

GEAR SHAPING MACHINE OH4

For rapid production of internal and external spur, single and double helical gears, segment gears, ratchets, cams.

	External	Internal
Maximum diameter of spur gears	7¾ in.	6½ in.
Maximum diameter of helical gears	7½ in.	6½ in.
Minimum gear diameter	⅜ in.	1½ in.
Maximum gear width	1½ in.	1⅜ in.

Maximum pitch 4 Mod. (6 DP)

DELIVERY EX STOCK

Our showrooms are only a few minutes from London Airport

Exclusive Distributors in the United Kingdom.

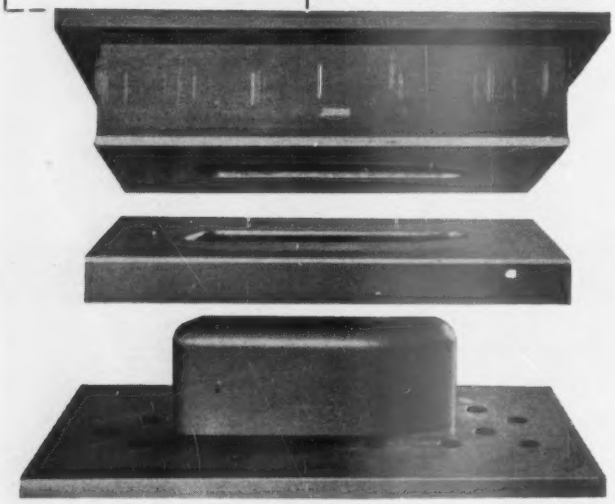
ELGAR *Machine Tool Company Limited*
HAMPTON ROAD WEST · HANWORTH · FELTHAM · MIDDLESEX
Phone: FELTHAM 4266 Cables & Grams: SHIPMENTS, FELTHAM

Illustration shows Hy-du-lignum Raising Tool for mild steel petrol tank pressings.

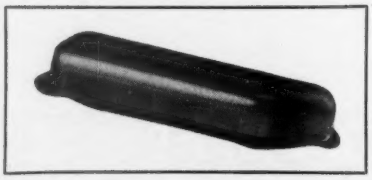
Photograph by courtesy of Weathershields Ltd.

Mechanical press tool designers naturally prefer—

Hy-du-lignum & Jabroc
LAMINATED COMPRESSED WOOD



- One-fifth the weight of steel.
- Low cost. • Speedy manufacture.
- Supplied as finished tools or as board.



Please write for illustrated brochure SL/8 to:

HYDULIGNUM-JABROC (TOOLS) LTD.
Associated with Hordern-Richmond Ltd.

Designers and manufacturers of jigs and tools in Hy-du-lignum · Jabroc · Steel · Hyroc (paper based laminate) · Glass Fibre.

Head Office: Hy-du-lignum Works, Haddenham Bucks. *Tel.*: Haddenham 444-446. *Grams.*: Winstix, Aylesbury
Northern Office: 89 Oxford Street, Manchester, 1. *Tel.:* Central 9364/5/6
Jig and Tool Works: Mill Lane, Waddon, Croydon. *Tel.*: Croydon 2201

How many wheels did you say?

Around 12,000 a day—for cars, vans, buses, trucks, tractors, trailers. Not surprising when you consider that Sankey's, the first to make the pressed steel vehicle wheel, are the largest producers in Europe. Press facilities up to 2,000 tons, welding capacity up to 1,200 K.V.A., specialised conveying systems, full painting equipment—all combine at Wellington to provide industry with everything it requires in the way of wheels.

If it's a big job call in

Sankey OF WELLINGTON

JOSEPH SANKEY & SONS LTD., HADLEY CASTLE WORKS, WELLINGTON, SHROPSHIRE.
TELEPHONE: 4321 WELLINGTON, SHROPSHIRE. TELEGRAMS: SANKEY, WELLINGTON, SHROPSHIRE.

Precious little in it for you?

If spraying is part of the operation, you can save on costly labour time by using the *right* Masking Tape for the job. Here is a thin, MORE FLEXIBLE tape which can be quickly applied by the most inexperienced labour and yet ensure a perfect job.

Sellotape
REGD. TRADE MARK
Masking Tape
for a perfect start to a perfect finish

Sellotape is the Registered Trade Mark of Adhesive Tapes Ltd.

POST TODAY FOR FULL DETAILS
to the Sole Distributors in the U.K.
The INDUSTRIAL SELLOTAPE DIVISION of Gordon & Gotch Ltd., 8-10 Paul Street, London, E.C.2. Telephone: BIShopsgate 6511
Please send me more information about Sellotape Masking Tape

Name.....

Address.....

.....

G&G

"The trouble is, he's a new G.G.L. fan, and they always go on and on about G.G.L. Service and Quality when they first discover it. Mind you, it is wonderful the way you get accurate, top quality work at the right price and the right time."
—"Don't talk to me about time," mutters the waiter.

CAPSTAN AND AUTOMATIC WORK AND SHEET METAL PRESSINGS IN ANY METAL, ANY FINISH, ANY QUANTITY

G·G·L

FOR QUICK SERVICE AT THE RIGHT PRICE GET IN TOUCH WITH:
GRIFFITHS, GILBART, LLOYD & CO. LTD.
Empire Works, Park Road, Birmingham, 18. Telephone NORthern 6221.

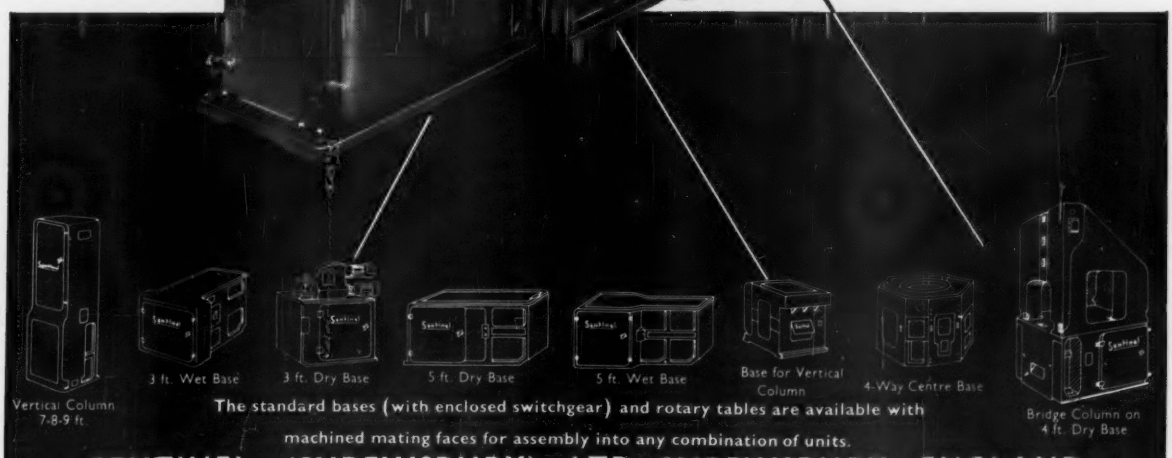
Sentinel UNIT MACHINES

FAST VERSATILE ECONOMICAL

SENTINEL UNIT MACHINES incorporating the Renault-France system electro-mechanical heads.
Built for—Drilling, Boring, Facing and Chamfering. 8 different types of Manifolds (see *inset*). Two manifolds are loaded, pneumatically located and clamped.
Press a button to start—and in less than 30 seconds the machining cycle is completed!

AN EXAMPLE OF FLEXIBILITY

This Unit Machine comprises a
3 ft. Dry Base, and an EMH 10 with Boring, Facing and Chamfering Tools.
3 way Centre Base.
4 ft. Dry Base, and an EMH 10 with Boring, Facing and Chamfering Tools.
Bridge Column, and an EMH 20 with a 12 multi-spindle head.


Vertical Column 7-8-9 ft
3 ft. Wet Base
3 ft. Dry Base
5 ft. Dry Base
5 ft. Wet Base
Base for Vertical Column
4-Way Centre Base
Bridge Column on 4 ft. Dry Base

The standard bases (with enclosed switchgear) and rotary tables are available with machined mating faces for assembly into any combination of units.

SENTINEL (SHREWSBURY) LTD SHREWSBURY ENGLAND

Telephone: SHREWSBURY 2011 Telegrams: "SENTNOLL SHREWSBURY" London Office: 15 CONDUIT STREET, LONDON, W.1 Telephone: MAYFAIR 2675

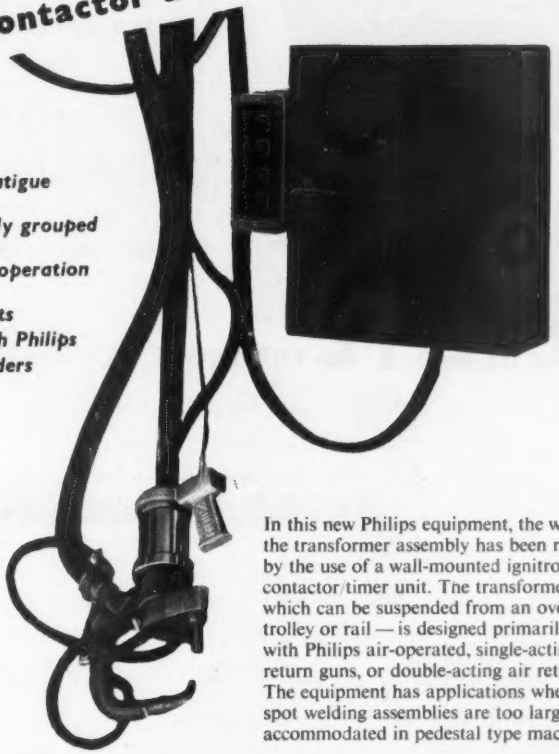
P4138

Accepted throughout the motor industry
as the most efficient Water Pump Seal
The ROMET
DIAPHRAGM SEAL
A SUPERFECT PRODUCT
Judge a product by its users —
B.M.C.
LEYLAND
A.E.C.
VAUXHALL
FORD
STANDARD
FERGUSON
HUMBER
ARMSTRONG-SIDDELEY
PERKINS
CONCENTRIC MANUFACTURING CO.
RUBERY OWEN
SUPER OIL SEALS & GASKETS LTD FACTORY CENTRE BIRMINGHAM 30

Clarkson
CLARKSON ½ HSS
CLARKSON ½ HSS
Autolock CUTTERS
Head Office and Works: NUNEATON
Branches at: Newcastle · London · Birmingham · Bristol · Manchester · Glasgow · Belfast · Leeds

Transformer Assembly *Rated at 30, 40 or 60kVA, each available for one or two gun operation. Multi-position tap-link panel for wide range of heat control. Fully water-cooled and tropicalized.*

Philips portable gun welding equipment... ignitron contactor and electronic timer



Contactor/Timer Unit *— for wall mounting. Ignitron contactor and four-function timer for automatic control of complete welding sequence. Available with duplicate timers for independent double-gun operation. Size: 30" x 30" x 10" deep.*

- ***Reduced operator fatigue***
- ***Controls conveniently grouped***
- ***For one or two gun operation***
- ***Standard components interchangeable with Philips spot/projection welders***

In this new Philips equipment, the weight of the transformer assembly has been reduced by the use of a wall-mounted ignitron contactor/timer unit. The transformer — which can be suspended from an overhead trolley or rail — is designed primarily for use with Philips air-operated, single-acting spring return guns, or double-acting air return type. The equipment has applications wherever spot welding assemblies are too large to be accommodated in pedestal type machines.

Write for leaflet PI.4869 which gives full technical details.

METAL PROCESSING DEPARTMENT

PHILIPS ELECTRICAL LTD

INDUSTRIAL PRODUCTS DIVISION

Century House · Shaftesbury Avenue · London · W.C.2

(PI0238)

Britain's Roman Highways

ICKNIELD STREET

When the Romans invaded Britain they were faced with the problem of creating suitable highways which would give their legions access to the ends of the country. Of the many they built, the most important and famous were the Four Ways; Watling Street, The Fosse, Ermine Street and Icknield Street.

Icknield Street stretched from Norfolk to Southampton and is the one most likely to have been in existence at the time of Caesar's first invasion for it lacks directness, the first characteristic of a true Roman Road. It does not communicate with any ancient town but passes close to some prehistoric remains that are mostly British, such as the Berkshire White Horse and Stonehenge.

It winds from Chesterford through Dunstable, Wendover, along the Chilterns, crosses the Thames near Streatley, and runs on to the Ancient Temple at Avebury.

* Richard Berry have been actively concerned in improving the passage of vehicles over the roads of Britain and the World for over a hundred years. Today the tradition of their skilled craftsmen is being kept alive by the products of their new road spring factory.

R B TRADE MARK

write for your copy of
"LEAF SPRING DESIGN"
by Alan Hodgson

CARRY ON BERRY

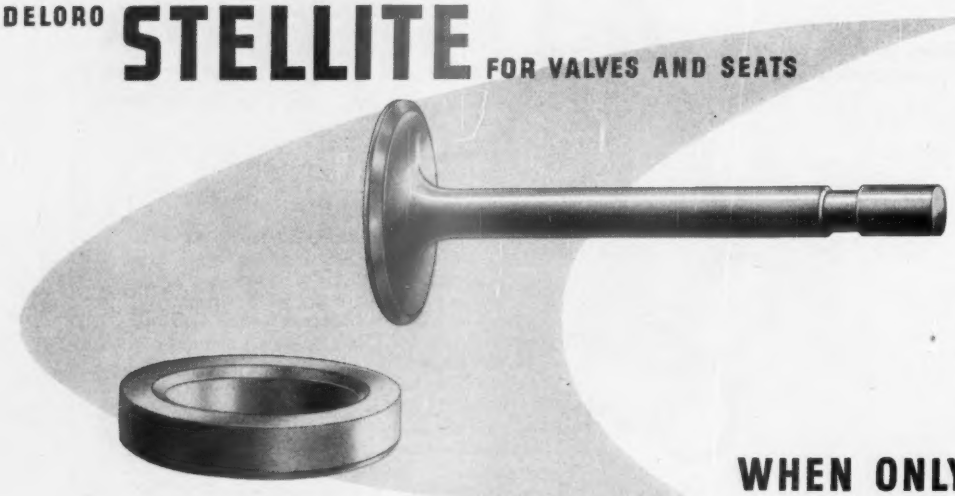
RICHARD BERRY & SON, WEST BROMWICH, STAFFS.
Tel: West Bromwich 1766-7-8.

ONE OF THE BROCKHOUSE COMPANIES

THE CHOICE OF ROLLS ROYCE FOR 20 YEARS

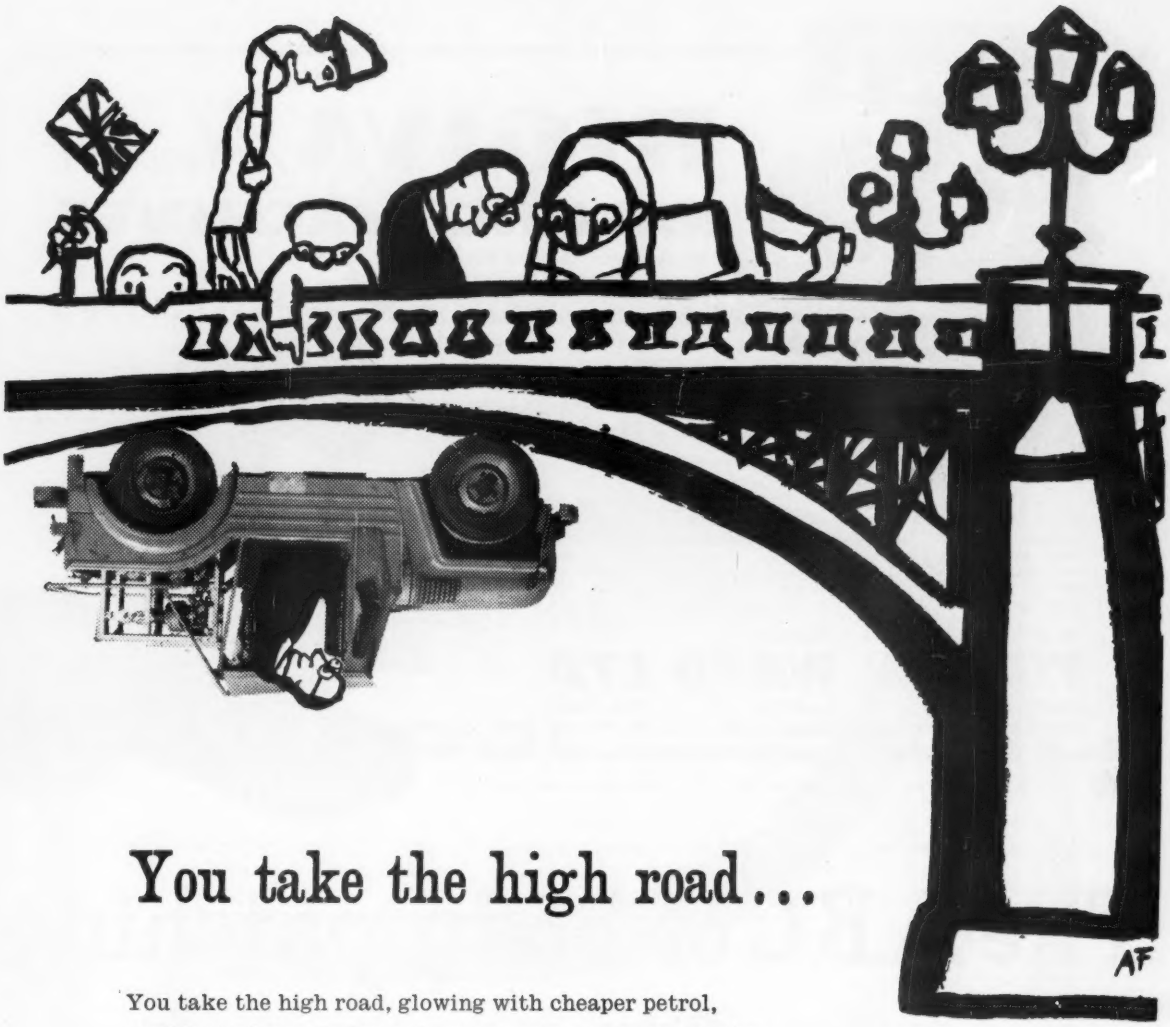
ROLLS RR ROYCE

DELORO **STELLITE** FOR VALVES AND SEATS



WHEN ONLY THE BEST IS ACCEPTABLE

DELORO STELLITE LIMITED · HIGHLANDS ROAD · SHIRLEY · SOLIHULL · WARWICKSHIRE · ENGLAND
DIV. OF DELORO SMELTING & REFINING CO. LTD. · BELLEVILLE · ONTARIO · CANADA



You take the high road...

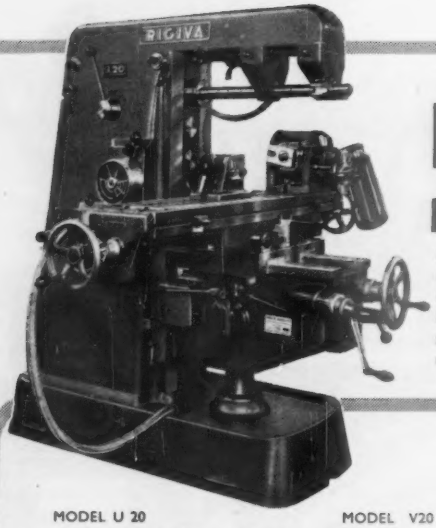
You take the high road, glowing with cheaper petrol, confident of your judgment, your engine, your suspension, your brakes, your everything . . .

We'll take the low road, doggedly making sure your car's locks never fail you. You take it easy . . . We'll be out on a corrugated track for six days at a time, dragging one swooning driver after another from the wheel of our special, squat, welterweight testing vehicle.

You enjoy yourself . . . We'll be out there pitching and tossing, over Belgian pavé and herringbone-wrinkle, up and up the Thirty-nine steps and down the rocky glen, testing new prototype locks under what we always refer to as "actual road conditions".

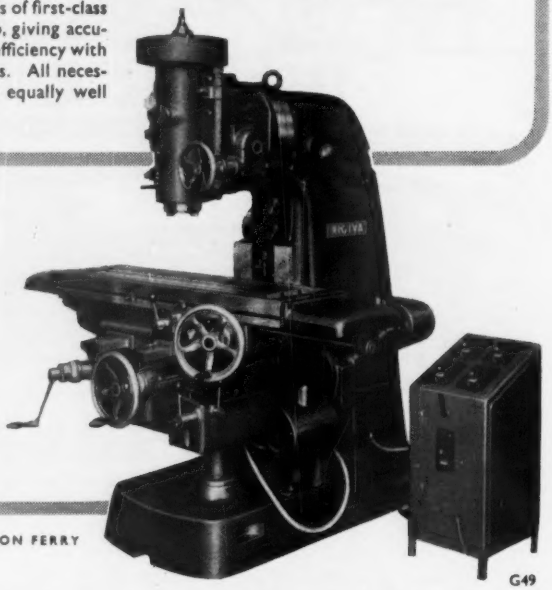
The findings, automatically recorded, are important both to us and to you. They go to explain why Wilmot Breeden components — locks, handles, bumpers, window-winders, steering-wheels and all — are part of virtually every British car on the actual roads today.

Wilmot Breeden are at Birmingham: *also at London, Manchester, Bridgwater, Glasgow, Melbourne, Toronto.*



RIGIVA *Precision*
MILLING MACHINES

are excellent examples of first-class modern workmanship, giving accuracy and operational efficiency with low maintenance costs. All necessary attachments are equally well designed.



MODEL U 20
Universal; table working surface 55" x 11½", power longitudinal traverse 43½", cross traverse 13½", table rise and fall 13½", spindle nose 2¼", International Taper.

MODEL V20 B
Vertical; table working surface 55" x 13½", power longitudinal traverse 43½", cross traverse 16⅝", table rise and fall 17½", spindle nose 2¼" International Taper.

Sole Selling Agents for United Kingdom

THOS. W. WARD LTD

ALBION WORKS · SHEFFIELD · TEL: 26311
LONDON OFFICE: BRETTENHAM HOUSE, STRAND, W.C.2 · TEL. TEM 1515

★ MACHINERY SHOWROOMS ALSO AT SILVERTOWN · GLASGOW · BRITON FERRY

G49

The A.B.C. of body patching

Abbey — tin-rich, top quality solder for all work where fine finish is essential.

Belfry — another pure solder by FRY'S for general work.

Cloister — an inexpensive body solder for use where economy is essential.

All in 1-lb. flat bars.

And for the fastest pre-tinning . . .

FRYOLUX Solder Paint

Simply brush on, go over with the flame and the job is ready for patching!

Please write or phone for further details to:-

FRY'S *Metal Foundries Limited*

Tandem Works, Merton Abbey, LONDON, S.W.19
Tel. MITcham 4023

And at MANCHESTER · GLASGOW · BRISTOL · DUBLIN

M.R.P. 64 B

AGRICULTURE

AUTOMOTIVE INDUSTRIES · EARTH MOVING

MACHINE TOOLS · MECHANICAL HANDLING

MARINE ENGINEERING

GAS INDUSTRY

WHATEVER THE JOB

THERE'S A

DUNLOP

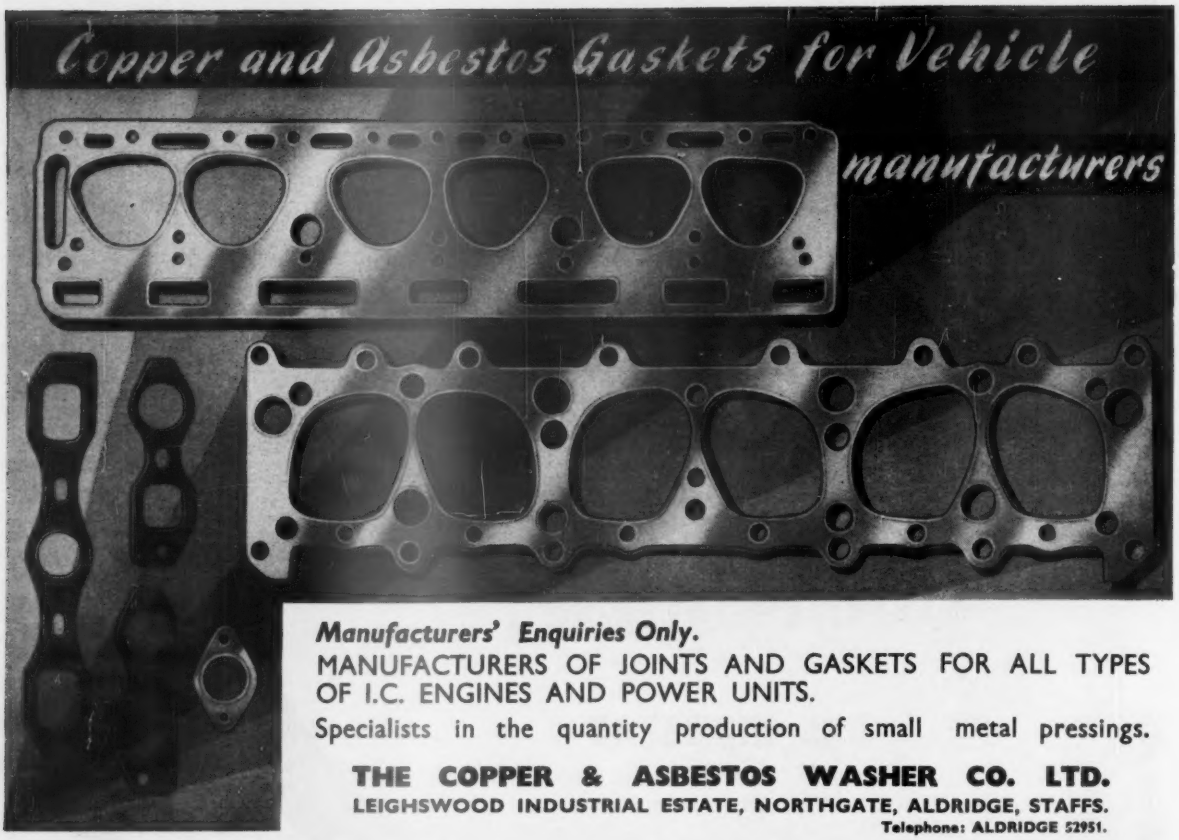
FLEXIBLE PIPE

TO CARRY IT THROUGH

Dunlop Technicians will always advise on any problems concerning installation of Flexible Pipes, write please to :—

DUNLOP RUBBER COMPANY LIMITED · ST. GEORGE'S ROAD · COVENTRY · TELEPHONE: COVENTRY 84171

6M/903



Manufacturers' Enquiries Only.

MANUFACTURERS OF JOINTS AND GASKETS FOR ALL TYPES OF I.C. ENGINES AND POWER UNITS.

Specialists in the quantity production of small metal pressings.

THE COPPER & ASBESTOS WASHER CO. LTD.

LEIGHSWOOD INDUSTRIAL ESTATE, NORTHGATE, ALDRIDGE, STAFFS.

Telephone: ALDRIDGE 52951.

VOLVO

DIESEL VEHICLES AND CARS

Sweden

USE

CLANCEY

CHILLED FACED CAST-IRON TAPPETS

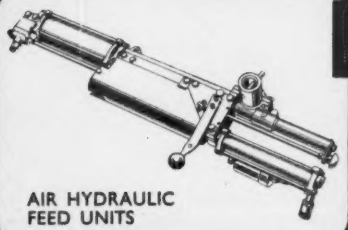
G·CLANCEY LTD · BELLE VALE · HALESOWEN

THE LARGEST MANUFACTURERS OF VALVE GUIDES AND TAPPETS IN EUROPE

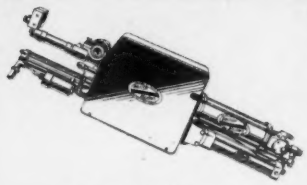
TELEPHONE: CRADLEY HEATH · 69411-2-3

AUTOMATION through Controlled Air Power gives Faster, Safer and Better Production

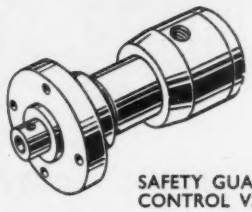
See for yourself how the application of pneumatic devices can aid increased production and efficiency as shown by two short films "Production Miracles" and "Operation Push Button" produced by the Bellows Corporation of Akron, Ohio, U.S.A., and available for exhibition on request.



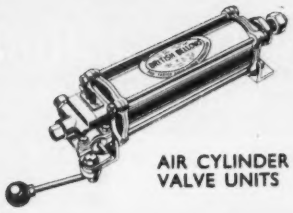
AIR HYDRAULIC FEED UNITS



AIR HYDRAULIC DEEP HOLE DRILLING UNITS

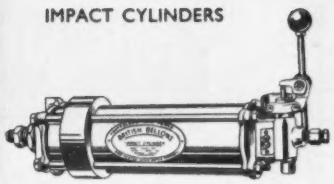


SAFETY GUARD CONTROL VALVES



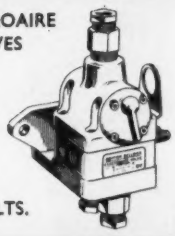
AIR CYLINDER VALVE UNITS

IMPACT CYLINDERS

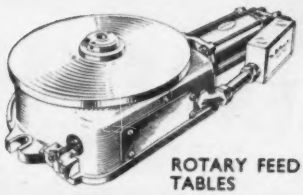


SINGLE ACTING HYDRAULIC CHECK CYLINDERS

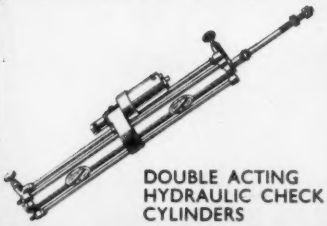
ELECTROAIRE VALVES



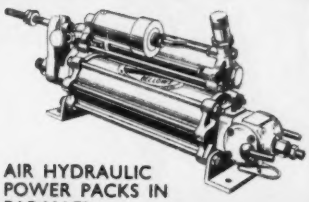
8 VOLTS. 3 SIZES



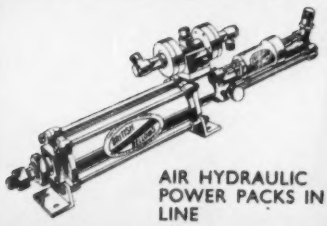
ROTARY FEED TABLES



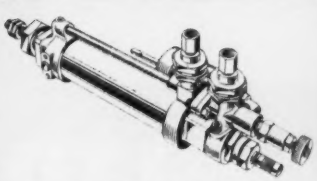
DOUBLE ACTING HYDRAULIC CHECK CYLINDERS



AIR HYDRAULIC POWER PACKS IN PARALLEL



AIR HYDRAULIC POWER PACKS IN LINE



HYDRAULIC CHECK CYLINDERS WITH SKIP AND STOP CONTROLS

BRITISH BELLOWS

PNEUMATIC EQUIPMENT

Manufactured under licence by

GEO. H. HUGHES LTD. BIRMINGHAM 24

Sole Distributors :— **BENTON & STONE LTD.**

ASTON BROOK ST., B'HAM 6

Telephone : AST 1905

(from where films and literature are available on request)

you design...
we manufacture...
MECHANICAL RUBBER COMPONENTS for automobile & aircraft production
Send your "Problem piece" for our quotation
THE SHERBORNE RUBBER CO LTD
SHERBORNE STREET · BIRMINGHAM · 16 phone: EDG 3881-2-3

EAGLE BRAND
DROP FORGED
SPANNERS
DROP FORGINGS
OF QUALITY
FOR ALL PURPOSES
V
B
W
VAUGHAN BROS (DROP-FORGINGS) LTD.
EAGLE WORKS · WILLENHALL · STAFFS.

universal
steel & metal
service
FROM STOCK
Morleys
(B'HAM) LTD.
Regina Works, Alcester Street, Birmingham, 12
Telephone: MIDland 6346 (6 lines) Telegrams "Capable, Birmingham".
LONDON WORKS
Viaduct Works,
North Circular Road,
South Chingford,
London, E4
'Phone: LARkswood 5221/2/3
MAKE A NOTE OF THE NAME
YOU'LL DO BETTER AT Morleys (B'HAM) LTD.

THE BUSY BEE FROM G&C says:

One of the powers that bee—that's me

Mine is the power that drives much of the finest plant in this country — and the power behind some of the finest electrical appliances as well.
Install me in your factory and you'll find me one of the liveliest workers on the payroll. And if you sell powered machines put me in them also. Your customers will like to see my good name added to yours. *They* know a good fractional too!
G.E.C. Fractionals give you the advantage of famed G.E.C. reliability at no extra cost. They are available in all standard ratings and with a full range of mountings.

G.E.C.

Fractionals

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

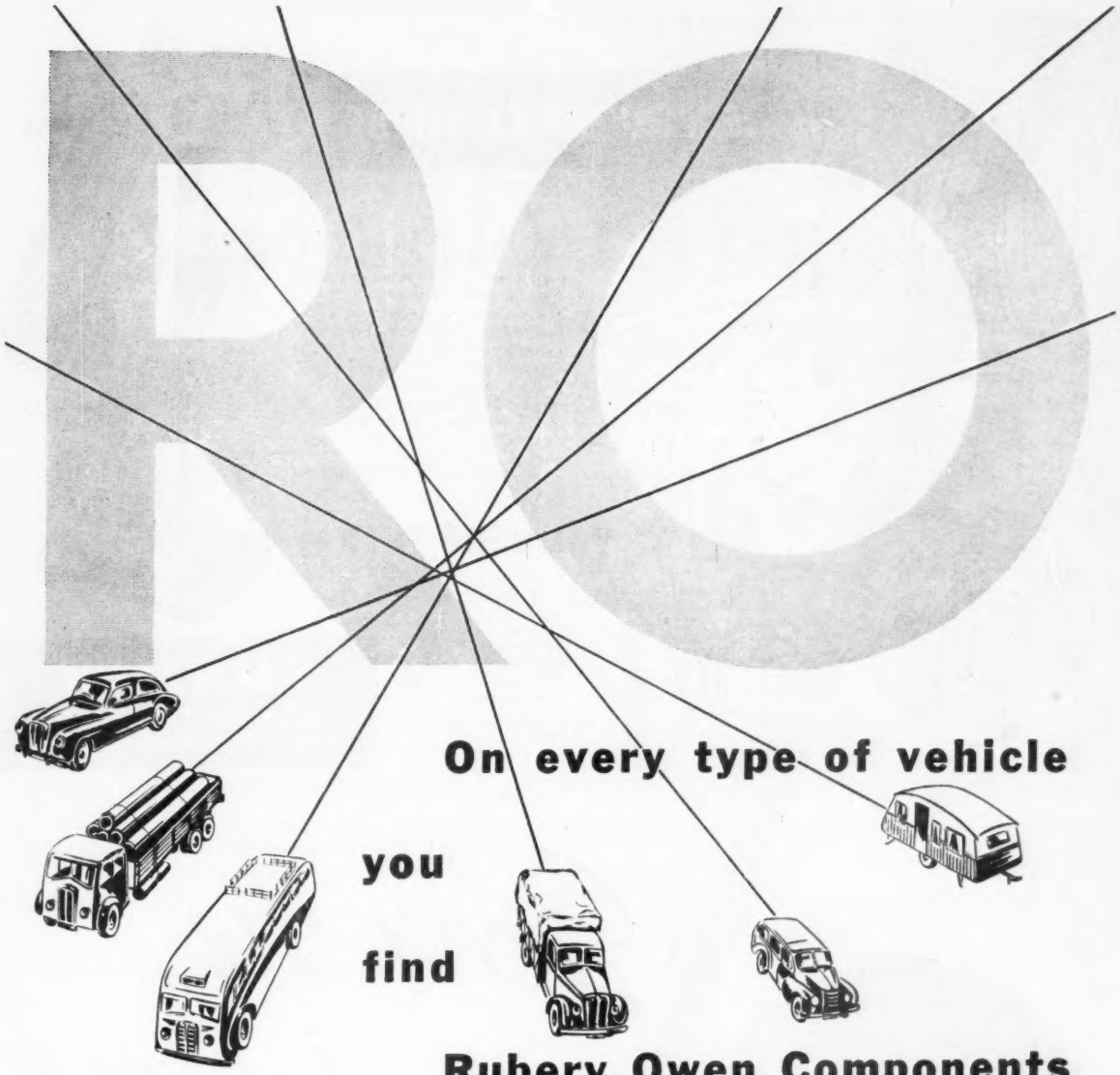
A GREAT 5 SPEED GEAR BOX

Suitable for maximum engine torque of 210 lb/ft. at 1,000 r.p.m. Overdrive can be fitted if desired.

Full specification and details on application.

MOSS GEARS

THE MOSS GEAR CO. LTD • CROWN WORKS • TYBURN • BIRMINGHAM 24 Phone: ERDington 1661-6 Grams: 'Mosgear, Birmingham'



On every type of vehicle

you

find

Rubery Owen Components

MOTOR DIVISION

COMPLETE CHASSIS FRAMES	(Commercial and Public Transport Vehicles, Trailers, Cars, and Caravans)
CHASSIS MEMBERS	(Commercial and Public Transport Vehicles and Trailers)
DEAD AXLES	(Commercial Trailer Axles 5-12 tons (with brakes) Caravan and Trailer Axles. Straight Beam 15-50 cwts. / Dropped Beam 15-40 cwts. } (with or without brakes)
REAR AXLE CASINGS	(Commercial and Public Transport Vehicles, Cars)
ROAD WHEELS AND DISCS	(Cars, Light Vans, Caravans, Light Trailers)
FUEL TANKS	(Commercial and Public Transport Vehicles, Cars)
PRESSINGS AND FABRICATED ASSEMBLIES	MACHINED ASSEMBLIES

BOLT & NUT DIVISION

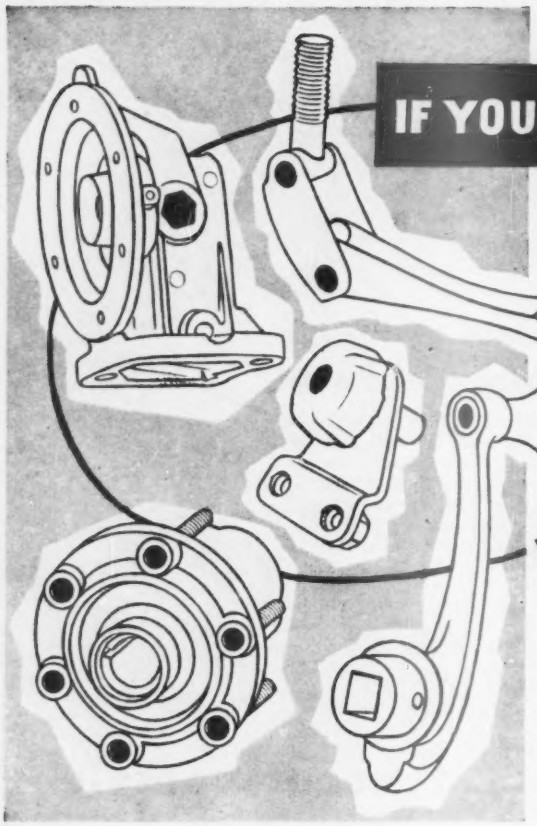
Coldheaded heat-treated Bolts, Setscrews, etc; Cold-formed Nuts; Bright turned Bolts, Nuts, Setscrews, Studs, Stud Bolts; Repetition parts; Bright Drawn Steel Bars.

Remember too, that our Wrexham factory specialises in the manufacture of all types of Storage Equipment for Spares and Service supplies and Steel Pallets for keeping production on the move.

RUBERY OWEN COMPONENTS

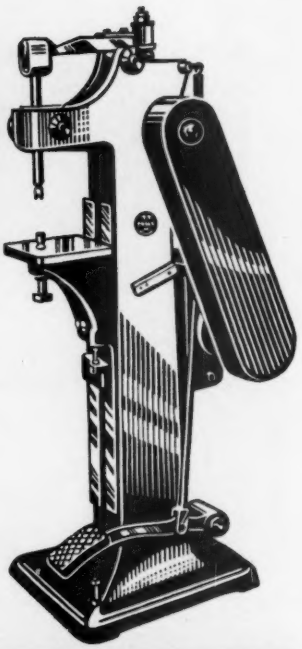
RUBERY, OWEN & CO. LTD., P.O. Box 10, Darlaston, Wednesbury, Staffs. Telephone : James Bridge 3131 (32 lines)

Member of the Owen Organisation.



IF YOU MAKE THESE

With these products, when rivets need to be headed close up against an angle or shoulder and when tight or loose heads are needed, the T.T. Rotary Vibrating Riveting Hammers should be your choice. The range copes with rivets from under $\frac{1}{16}$" to $\frac{3}{4}$" diam. in mild steel. Send us a sample of your product for completion. Snaps, anvils, tables and fixtures to suit requirements can be supplied.



YOU NEED THIS

We illustrate Model R.H. 14 MD. standard Machine (12in. throat model available) $\frac{1}{4}$" cap.

TURNER
MACHINE TOOLS LTD
63-68 · PRINCIP ST · BIRMINGHAM · 4

TELEPHONE: ASTON CROSS 2244

Seen the latest?

If you want to keep up-to-date on welding you cannot be without "SIP TIPS."

Published quarterly, it gives you all the latest news on Sifronze welding rods and processes and answers the kind of problems you are meeting every day.

To receive the magazine free of charge, fill in the coupon below. If applying on behalf of a company or organisation, please state the number of copies required.

THE EDITOR, "SIF TIPS," SUFFOLK IRON FOUNDRY (1920) LTD.
STOWMARKET, SUFFOLK.

Please send regularly.....copy/copies of "SIF TIPS."

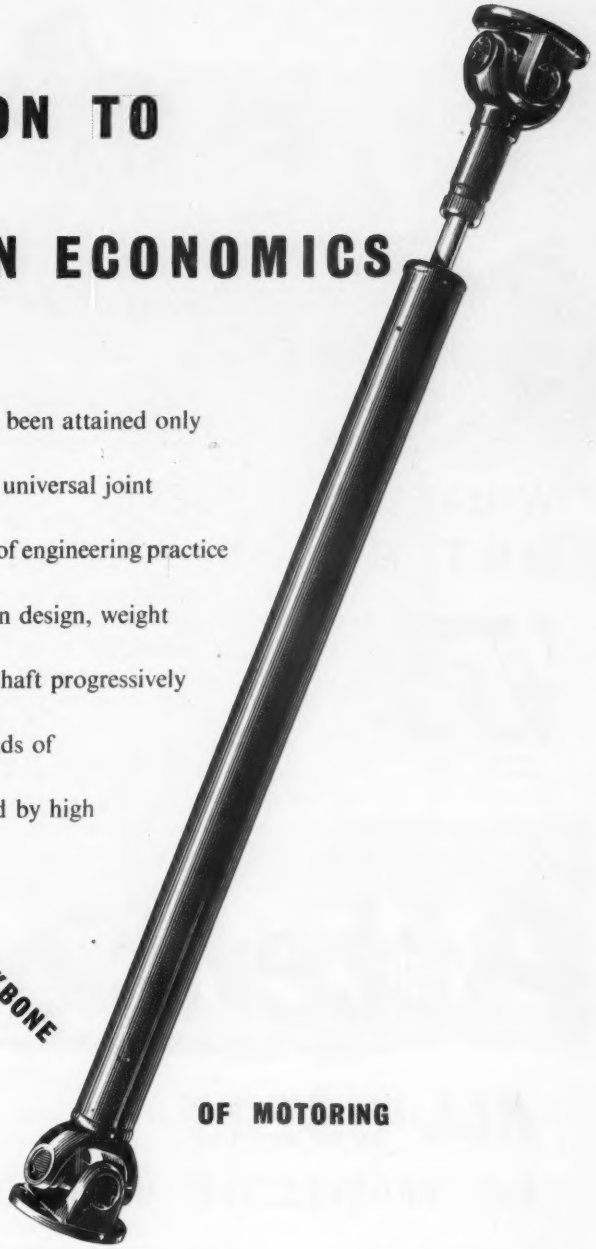
NAME .....

ADDRESS .....

.....

OUR CONTRIBUTION TO MASS PRODUCTION ECONOMICS

Our objective of a standardised propeller shaft has been attained only because—ever since we introduced our mechanical universal joint thirty-one years ago—we have kept in the forefront of engineering practice both as to design and manufacturing techniques. In design, weight has been progressively reduced ; balancing of the shaft progressively improved ; stricter tolerances imposed ; the demands of increased engine efficiency always anticipated. And by high specialisation in manufacture we provide this precision component at a bedrock price.



THE BACKBONE OF MOTORING

HARDY SPICER

PROPELLER SHAFTS

PRECISION-BUILT FOR EFFICIENCY ★ MASS-PRODUCED FOR ECONOMY

HARDY SPICER LIMITED (A Birfield Company) BIRCH ROAD · WITTON · BIRMINGHAM 6

WHERE ALL THE BEST

HOT BRASS PRESSINGS *COME FROM*

HPP

One of the SANBRA Group of Companies.

Here is a Works as modern as the minute, with the very latest in plant and equipment, planned to offer you the full benefits of specialised production—in the form of better quality, prompter deliveries, and keener prices. Whatever your needs in Hot Brass Pressings, Machined Pressings and Assemblies, you will find that H.P.P. can serve you better.

HOT PRESSED PRODUCTS

WHITEHALL ROAD, GREAT BRIDGE, TIPTON, STAFFS. *Telephone : TIPton 2731/2.*

Attention!

ALL USERS

AND PROSPECTIVE USERS OF

LIFTING AND OVERHEAD HANDLING EQUIPMENT!

In the U.K. it's NOW

ACROW (ENGINEERS) LTD.
SOUTH WHARF, PADDINGTON, LONDON, W.2
Telephone : AMBassador 3456 (20 lines)

*

ACROW (ENGINEERS) LTD. *are now SOLE AGENTS in the United Kingdom for*

DEMAG

—the world's most up-to-date
ELECTRIC HOIST BLOCKS, MONORAIL SUSPENSION TRACKS & SUSPENSION CRANES

*

From now on Acrow will supply all new Demag equipment; supply all spare parts and take over the servicing of all existing installations

*

ACROW DEMAG

Branches at : Birmingham *(Walsall 6085)* ; Bristol *(Bristol 655244)* ; Leeds *(Leeds 76514)* ; Liverpool *(Aintree 7335)* ; Manchester *(Deansgate 7045)*; Newcastle *(Newcastle 86-9493)*; Southampton *(Locks Heath 3021)*; Glasgow *(Bridgeton 1041)*.

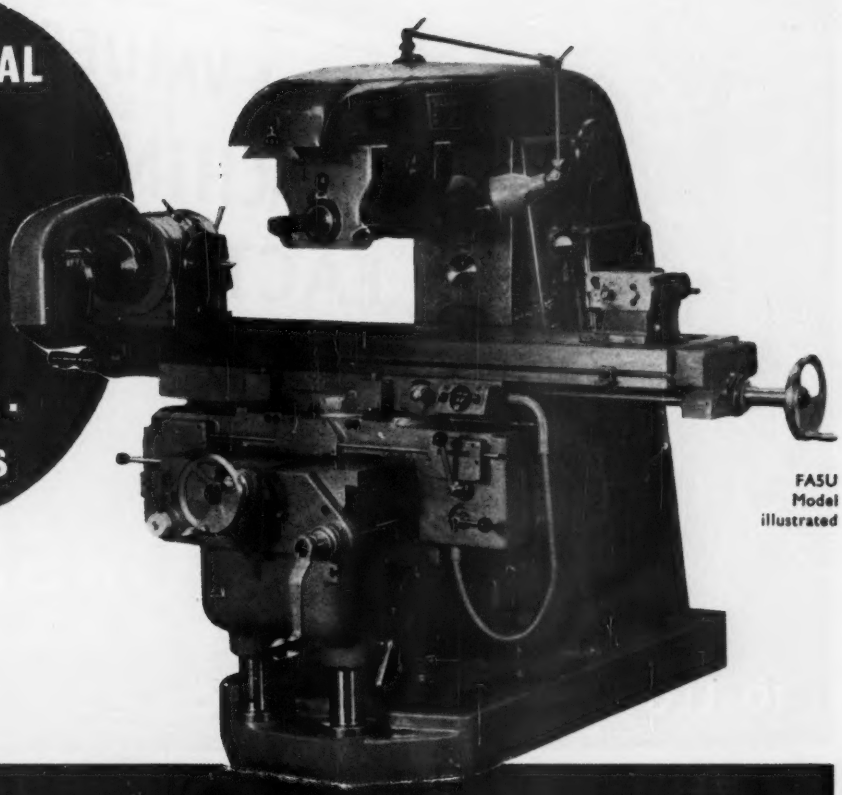
HORIZONTAL

UNIVERSAL

VERTICAL

All sizes . . .

. . all types



FA5U
Model
illustrated

ZBROJOVKA MILLERS

Early delivery of all models from London stock

BRIEF SPECIFICATIONS				
FOUR SIZES	No. 2	No. 3	No. 4	No. 5
Working surface of table (approx.)	40" x 8"	50" x 10"	64" x 12"	80" x 15"
Power longitudinal travel (approx.)	25"	32"	40"	50"
Power cross travel (approx.)	8"	9"	12"	15"
Spindle Speeds	63-2800	45-2000	32-1400	18-1400

SOLE AGENT

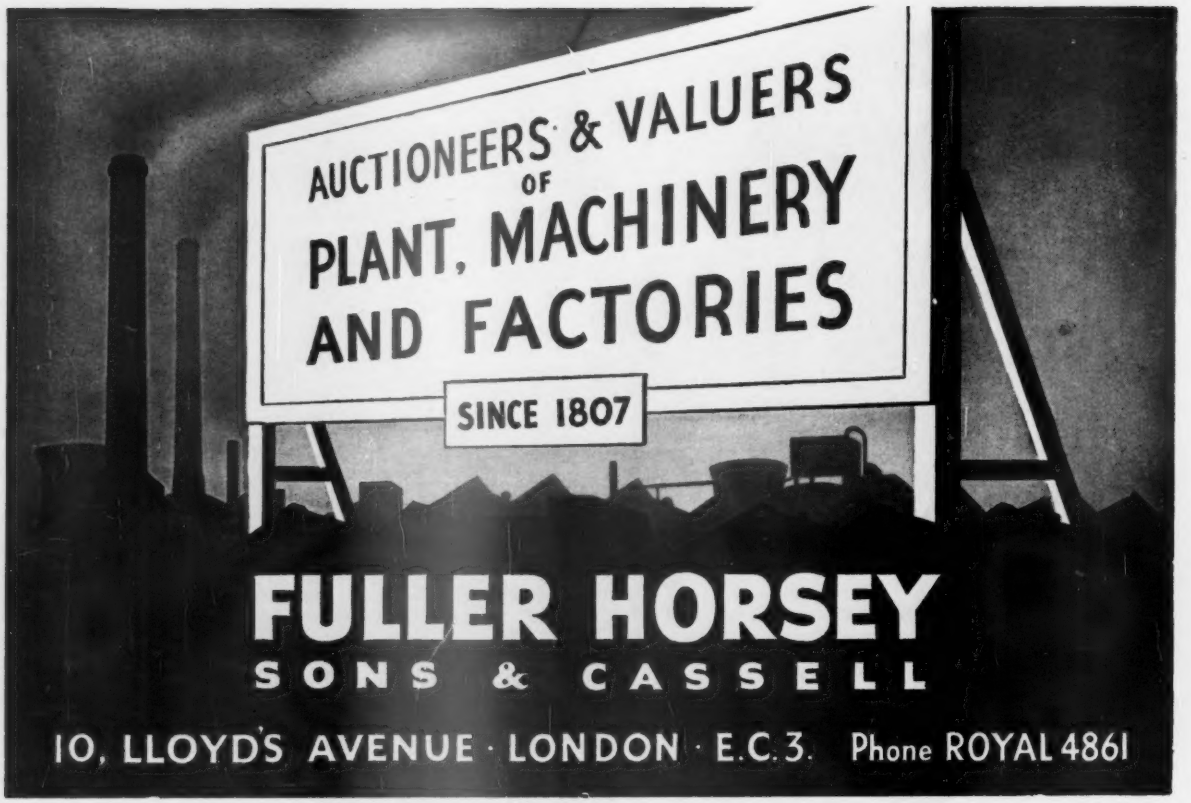
Selson
MACHINE TOOLS

The Selson Machine Tool Co. Ltd

CUNARD WORKS, CHASE ROAD, NORTH ACTON, LONDON, N.W.10

Telephone: Elgar 4000 (10 lines) Telegrams: Selsomachi, London

THE 600 GROUP



FULLER HORSEY
SONS & CASSELL

10, LLOYD'S AVENUE · LONDON · E.C.3. Phone ROYAL 4861

Rathbone

As cool as a...

...MARSTON RADIATOR

And that means just cool enough to get the finest performance from your engine. For Marston radiators strike the perfect balance between maximum cooling and optimum running temperatures. That's why they are fitted as standard on Britain's finest cars. What better recommendation for the quality and reliability of these famous products?

MARSTON EXCELSIOR LIMITED
WOLVERHAMPTON & LEEDS
(A subsidiary company of Imperial Chemical Industries Ltd.)

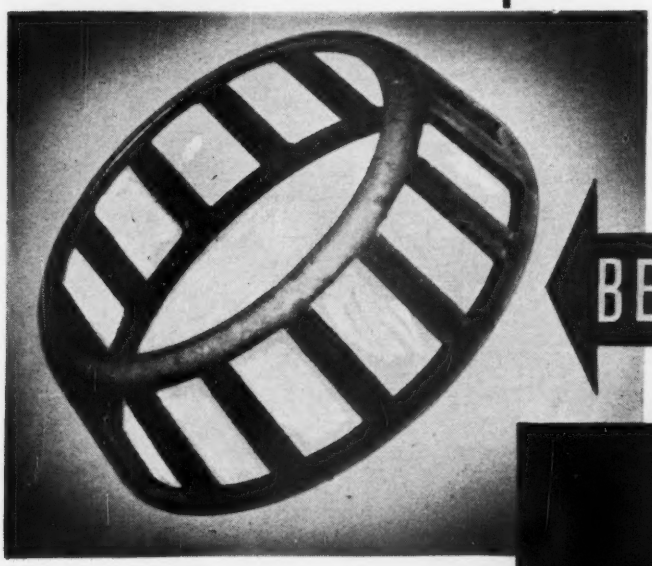
ICI

MAR 178A

What do you do about Deburring ?

ALMCO BARREL FINISHING SAVES YOU MONEY

1,000,000's of Tapered Roller Bearing Cages have been deburred and finished at the Duston, Northampton Works of British Timken Ltd. using *Almco Supersheen Materials and Methods.* Supersheen has *greatly expanded* the field for modern barrel finishing. It makes no difference whether you are a *small company or one of the "giants" of industry* and have already installed barrel finishing equipment. ALMCO Engineers will be pleased to show you how to improve your applications and get more work from your existing plant.
SMALL or LARGE there is an Almco Machine to fit your requirements.

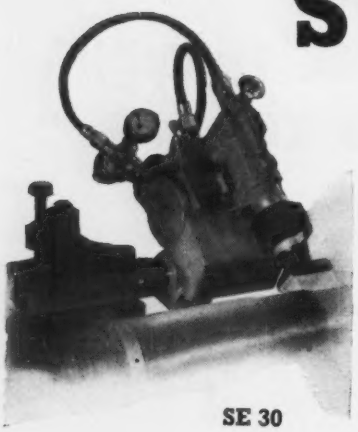


Write, Phone or call Dept. AER 1.

ALMCO

SUPERSHEEN
DIVISION OF GREAT BRITAIN LIMITED
BURY MEAD WORKS: HITCHIN, HERTFORDSHIRE
TEL: HITCHIN 3669
HEAD OFFICE: 46/47 CHANCERY LANE, LONDON, W.C.

SUPERFINISHING with SUPFINA ATTACHMENTS

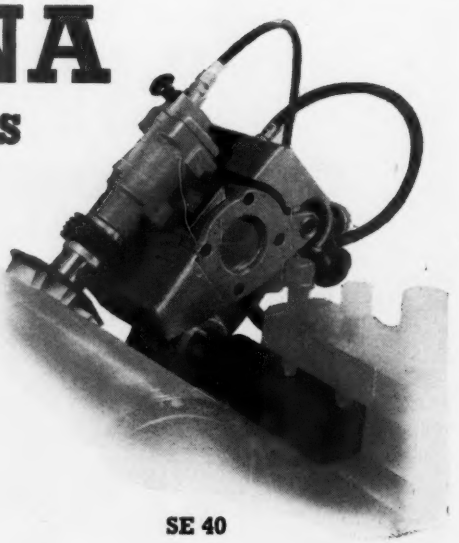


SE 30

Supfina attachments can be mounted on lathe toolposts for superfinishing any diameter of shaft. They are completely self-contained requiring only an air supply of approx. 80 lb. per sq. in.

SE 30. Suitable for a wide variety of work. Special equipment is available with this attachment which permits superfinishing crankshafts and similar deep work.

SE 40. Especially robust attachment for finishing rough surfaces and large components.



SE 40

CHARLES CHURCHILL & CO LIMITED

COVENTRY ROAD SOUTH YARDLEY BIRMINGHAM 25

BRANCHES LONDON GLASGOW NEWCASTLE MANCHESTER

WASHERS BY THE MILLION!
Manufacturers of :—
BRIGHT STEEL AND BRASS TURNED AND CHAMFERED WASHERS.
PLAIN BRIGHT STEEL AND BRASS WASHERS.
STEEL AND BRASS B.A. WASHERS.
ROOFING WASHERS.
ENGINEERS' BLACK WASHERS.
Odd Sizes a Speciality!

CHARLES (WEDNESBURY) LIMITED

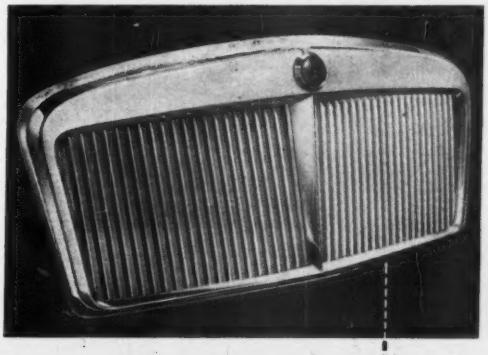
Telephone
WEDnesbury 0564-5

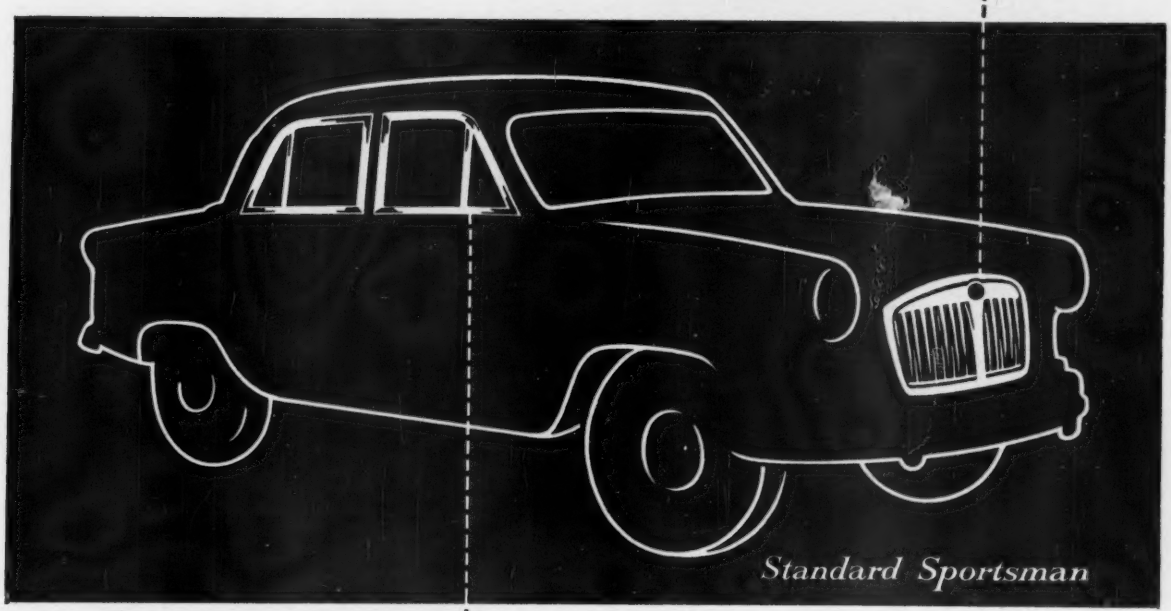
Telegrams
"CHAMFER, WEDNESBURY"

BRIDGE WORKS · WEDNESBURY · STAFFS

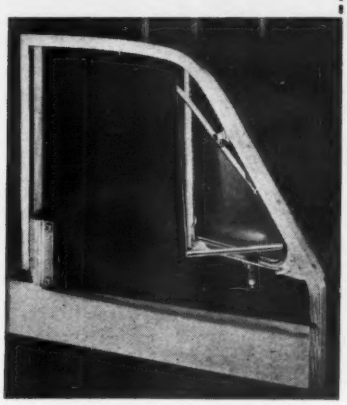
BIRMABRIGHT

Standard on the Sportsman





Engraved on 'Primag' Magnesium alloy plate



The radiator grille and windows of the Standard Motor Company Ltd.'s latest model are made of anodised Birmabright, and present a surface finish as durable as it is attractive.
More and more car manufacturers are turning to Birmabright, the well-tried aluminium-magnesium alloy which simplifies production problems and makes maintenance worry a thing of the past.

BIRMABRIGHT LIMITED · BIRMINGHAM 32 · BIRMETALS LIMITED

BM87

FOR SOUND CASTINGS

CONSULT

We are manufacturers of high duty iron castings for the motor car and allied trades.

As one example we show one of the biggest brake drums in use today — Cast by Triplex.

TRIPLEX FOUNDRY LTD

UPPER CHURCH LANE, TIPTON, STAFFS. *Telephone Tipton 1293*

HIGH DUTY IRONFOUNDERS

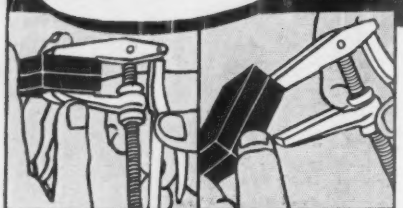
THE SIGN OF A GOOD CASTING

Another Revolution in Clamp Design!

Speetog

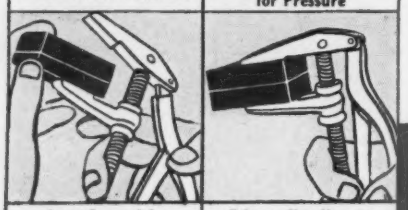
REGD. TRADE MARK

TOGGLE ACTION 'C' CLAMP



Lower Jaw Adjusted to Correct Distance

Workpiece Removed, Lower Jaw Adjusted for Pressure

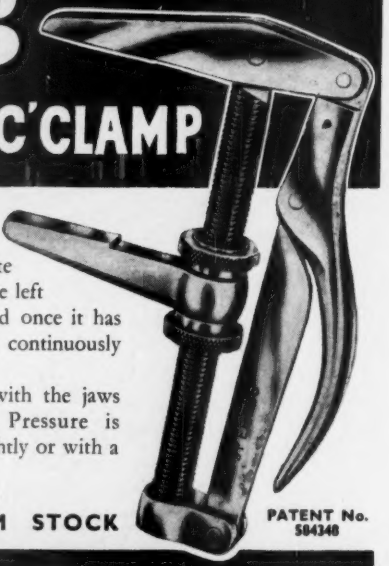


Jaws Opened by Trigger Handle to Insert Workpiece

Trigger Handle now Locks Jaws on Workpiece

The Speetog Toggle "C" Clamp is a self-locking tool which locks on to the work and holds it firmly gripped after quite simple adjustment. The illustrations at the left show how simple it is to set the tool and once it has been set to a definite size it will repeat continuously with the same pressure.

The tool will grip up to 3½" capacity, with the jaws parallel at all points of adjustment. Pressure is adjustable, so that the Clamp will grip lightly or with a heavy pressure as required.



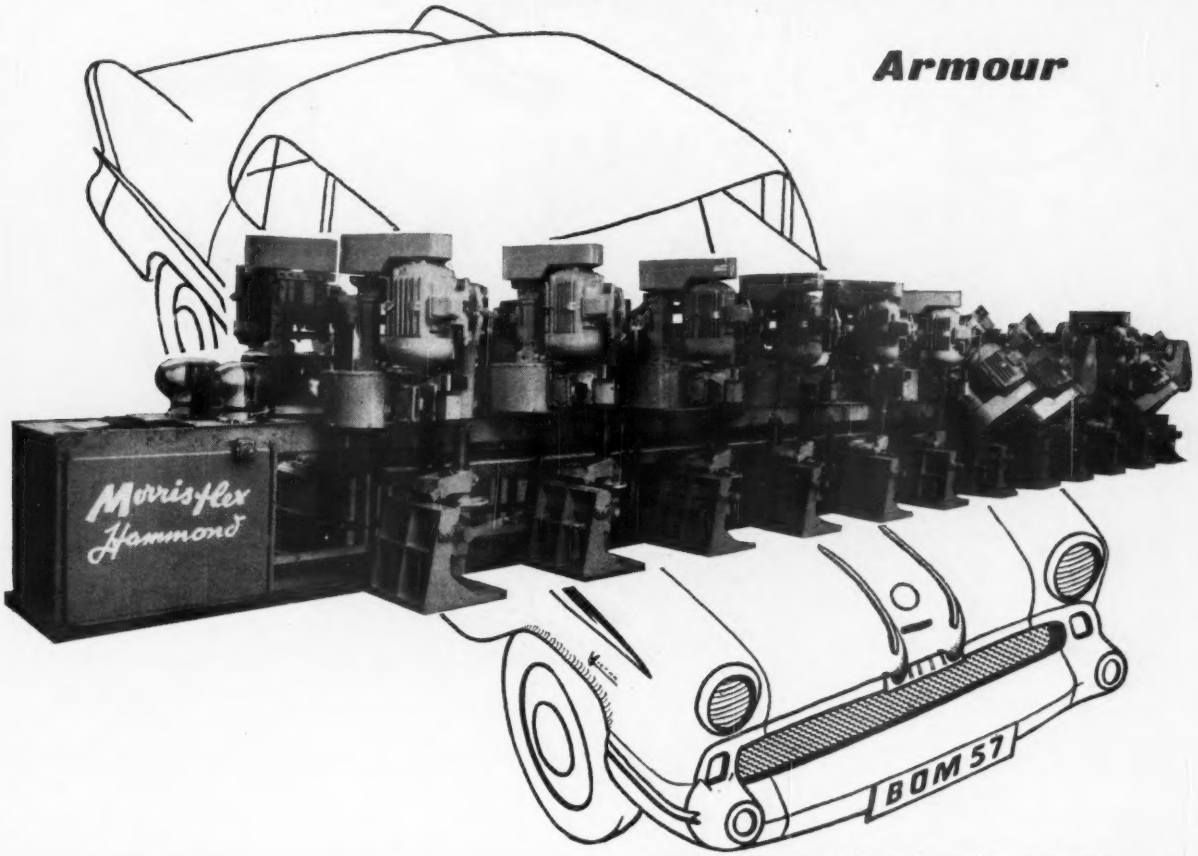
USUALLY AVAILABLE FROM STOCK

PATENT No. 584348

Speed Tools Ltd

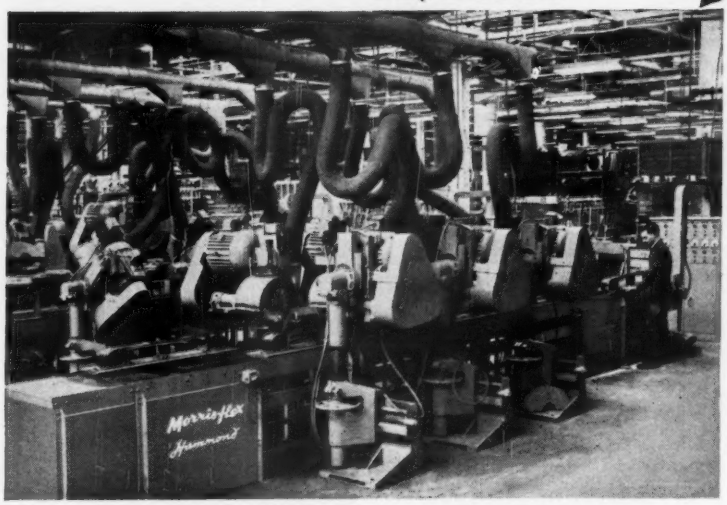
VEREKER BUILDINGS, GRESSE ST., LONDON W.1. Museum 1039/1099.

for polishing the VICTOR'S Armour



PHOTOGRAPHS BY COURTESY OF VAUXHALL MOTORS LTD.

VAUXHALL selected



Morrisflex Hammond

AUTOMATIC POLISHING MACHINES

B. O. MORRIS LIMITED
BRITON ROAD COVENTRY
Tel: COVENTRY 5081 Telegrams: MORISFLEX COVENTRY

also for :- HOLLOWARE BUILDERS' HARDWARE FANCY GOODS ETC.

'O' RINGS

Full range of British standard sizes available

BONDED Seals

Steel and rubber bonded joint washers for pressures up to 10,000 lb. square inch

'SELOCS'

The multi-purpose washer that locks, seals and protects

Enquiries invited for all types of mechanical seals and mouldings in P.T.F.E., synthetic, natural and silicone rubbers.

DOWTY Seals

DOWTY SEALS LIMITED • ASHCHURCH • GLOS

Member of the DOWTY GROUP

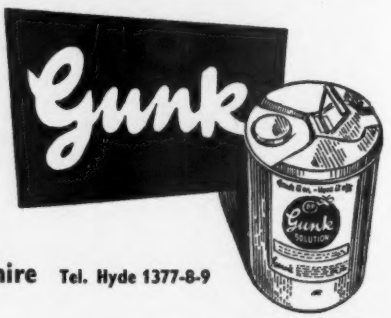
Telephone Tewkesbury 2271

The finest all round degreasant and cleaner

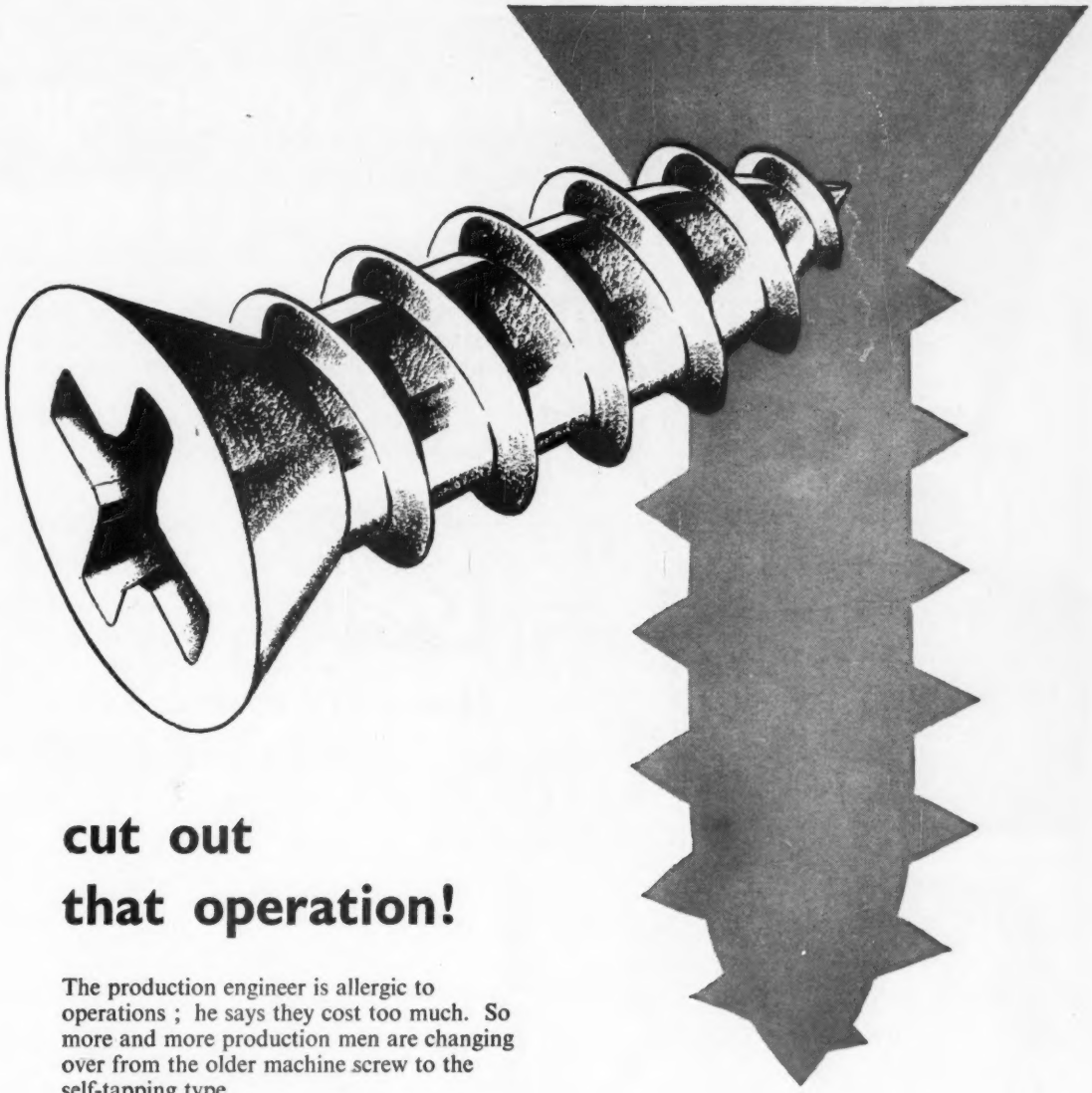
FOR ALL METAL PARTS, MACHINERY, FLOORS, WALLS, PAINTWORK, TILES, ETC.

Grease and oily deposits don't stand a chance when GUNK gets to work! Simply brush or spray GUNK on wherever is to be cleaned—rinse off with water—and see how all traces of grease and oil are instantly removed. So simple to use and so effective! There is no bothersome heating or mixing either. GUNK is supplied ready for use in 5, 10 and 40/45 gallon drums.

Send today for a free trial tin and see for yourself the remarkable cleaning powers of GUNK.



Manufactured by BENNETT (HYDE) Ltd. · Boston Mills · Hyde · Cheshire Tel. Hyde 1377-8-9



cut out that operation!

The production engineer is allergic to operations ; he says they cost too much. So more and more production men are changing over from the older machine screw to the self-tapping type.
For the self-tapping screw, by forming its own thread, cuts out completely all screw-cutting operations ; and, because of its self-locating point, greatly simplifies assembly. It never needs a nut, however thin the parts to be joined.
Moreover, the recessed-head type of self-tapping screw permits the use of power-drivers, without risk of harm to worker or work. The production men *have* something there, haven't they?

Linread

LINREAD LTD · COX ST · BIRMINGHAM 3

SLOTTED AND PHILLIPS RECESSED HEAD MACHINE SCREWS AND TAPPING SCREWS · HIGH TENSILE HEXAGON HEAD BOLTS AND SETSCREWS AIRCRAFT BOLTS, SCREWS AND RIVETS · SEMS · RIVNUTS · CUSTOM DESIGNED COLD FORGED FASTENERS · ALEX SCREWPLUGS.

Floating on air - thanks to permagic

Magnetic Floaters . . .

are indispensable wherever clean or greasy sheets of ferrous material have to be separated. Every press user should know of the tremendous saving in handling time which they effect.
Ask for publication P.M. 120, Part 1, which gives full particulars and sizes available.

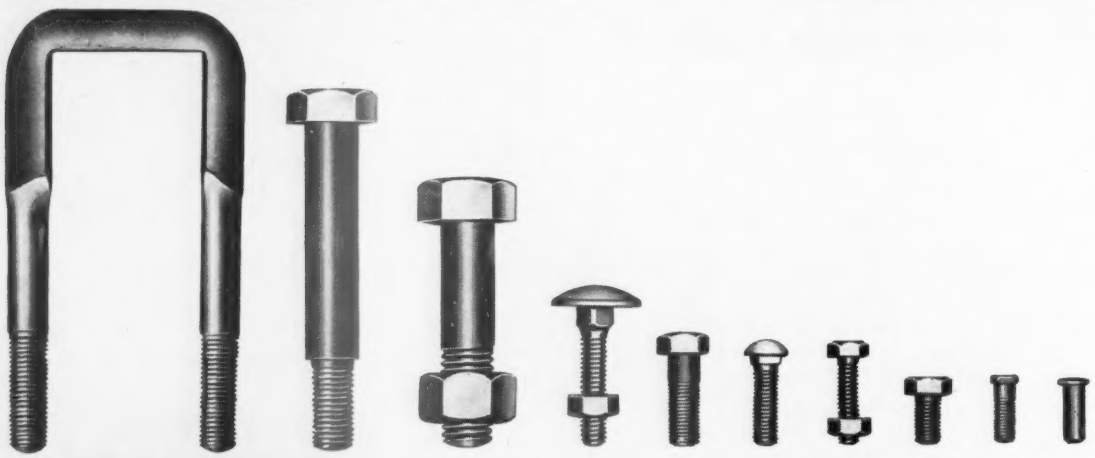
Eclipse

Supplies through appointed "Eclipse" Distributors

the only name for . . .
. . . magnetic tools

JAMES NEILL & CO. (SHEFFIELD) LTD., ENGLAND.

PM 125



WILEY

Whatever your fastening problem, Wiley can make a bolt for it—and a nut too—ask them !

make a bolt for it!

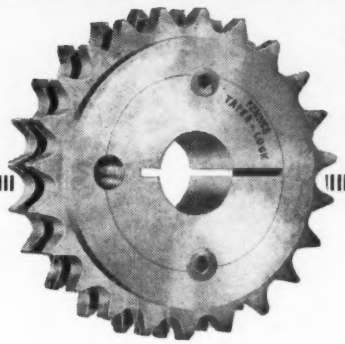
JAMES WILEY & SONS LIMITED, DARLASTON, STAFFS. *Telephone : James Bridge 2692.*

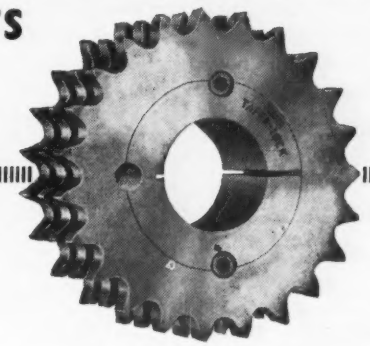
M-W.61

Fenner Taper-Lock bushes the fastest and simplest means of fixing to shafts, have now been extended to chain drives with

DUPLEX and TRIPLEX

SPROCKETS





THERE ARE OVER 500,000 TAPER-LOCK BUSHES IN USE WITHOUT A SINGLE FAILURE

TAPER-LOCK BUSHES GIVE YOU

- *EASY "ON-IN-A-MINUTE" FIXING*
- *REMOVAL BY ONE TWIST OF THE WRIST*
- *NO DELAYS DUE TO RE-BORING*
- *FURTHER USE AFTER SPROCKET IS WORN*
- *OFF-THE-SHELF DELIVERY FROM 18 BRANCHES*

J. H. FENNER & CO. LTD. HULL

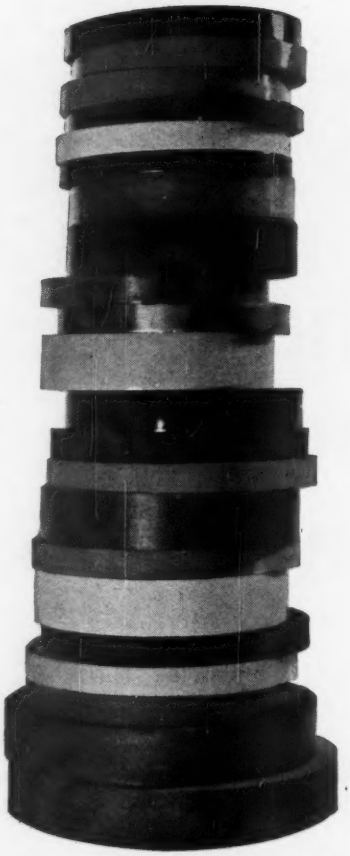
NEW BRANCHES NOW IN LEEDS & BRADFORD

LARGEST MAKERS OF V-BELT DRIVES IN THE COMMONWEALTH

Intal stands on its own good name

INTAL

THE INTERNATIONAL TWIST DRILL CO. LTD.
INTAL WORKS · WATERY ST. · SHEFFIELD · 3
Telephone : 23072-3 Telegrams : Fluted, Sheffield
OBTAINABLE FROM YOUR STOCKIST
London Stocks : 16, ALDERSGATE ST., E.C.1.
Phone: MON. 3505
Glasgow Stocks : 50, WELLINGTON ST., C.2.
Phone: CITy 6994



A TAPE FOR EVERY USE
PERMACEL SELF-ADHESIVE
TRADE MARK

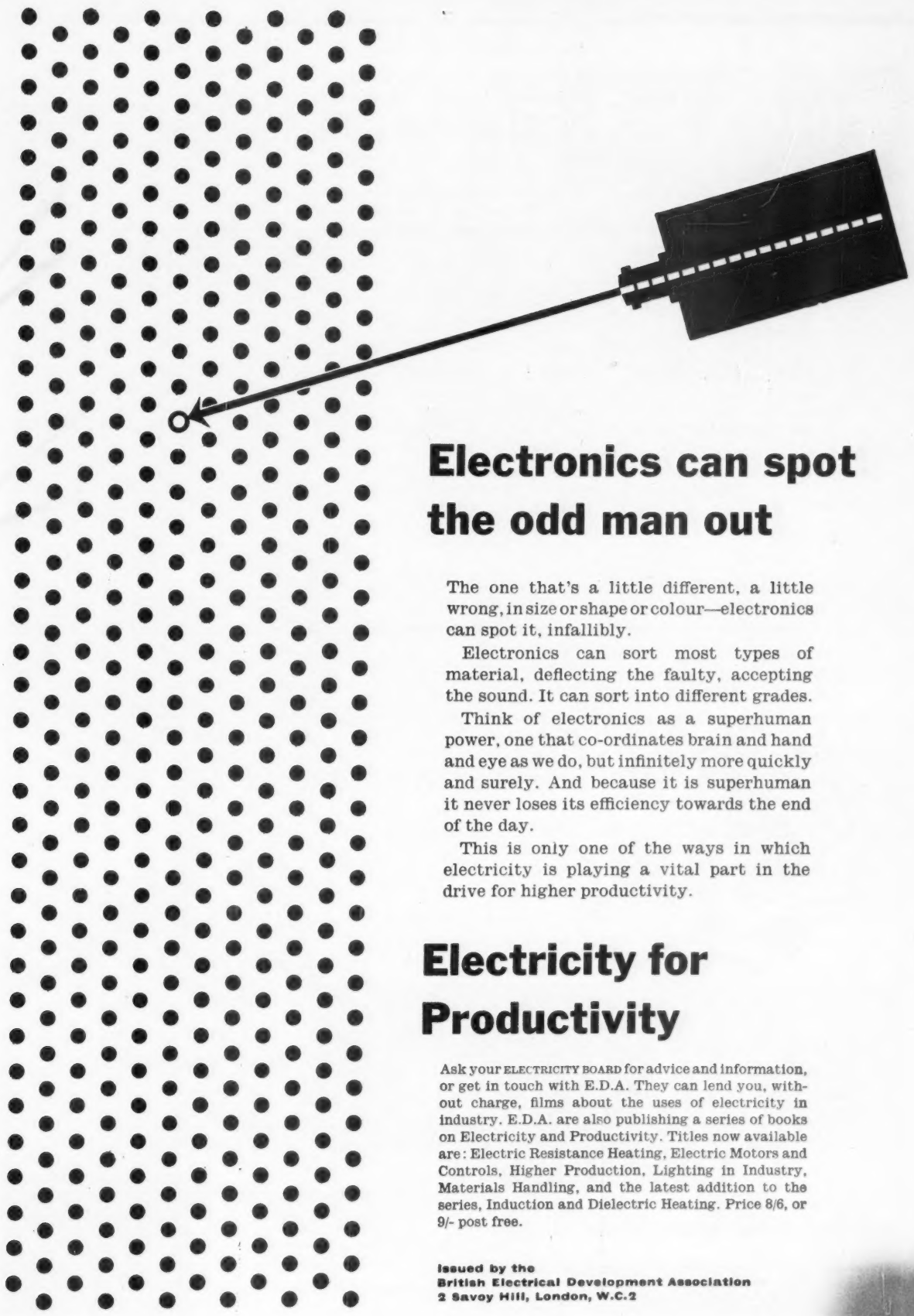
Cellulose Tape
P.V.C. (Unplasticised) Tape
Cloth Sealing Tape
Cloth Masking Tape
Paper Masking Tape
Waterproof Cloth Tape
Super Strapping Tape

For more information about Permacel Tapes and Dispensers write for a free copy of our Permacel Brochure. It contains over 400 ways in which Permacel has been used to save time and money in Packing and Production.

PERMACEL
TRADE MARK

INDUSTRIAL MASKING TAPES
INDUSTRIAL DIVISIONAL Dept. A.E.

Johnson & Johnson (GT. BRITAIN) LTD., SLOUGH, BUCKS.



Electronics can spot the odd man out

The one that's a little different, a little wrong, in size or shape or colour—electronics can spot it, infallibly.

Electronics can sort most types of material, deflecting the faulty, accepting the sound. It can sort into different grades.

Think of electronics as a superhuman power, one that co-ordinates brain and hand and eye as we do, but infinitely more quickly and surely. And because it is superhuman it never loses its efficiency towards the end of the day.

This is only one of the ways in which electricity is playing a vital part in the drive for higher productivity.

Electricity for Productivity

Ask your ELECTRICITY BOARD for advice and information, or get in touch with E.D.A. They can lend you, without charge, films about the uses of electricity in industry. E.D.A. are also publishing a series of books on Electricity and Productivity. Titles now available are: Electric Resistance Heating, Electric Motors and Controls, Higher Production, Lighting in Industry, Materials Handling, and the latest addition to the series, Induction and Dielectric Heating. Price 8/6, or 9/- post free.

Issued by the
British Electrical Development Association
2 Savoy Hill, London, W.C.2

P. M. HELDT S.A.E.

explains principles and practice in the American automobile industry

The Automotive Chassis

Without Power Plant. 3rd Edition. An authoritative exposition of American automobile practice. This valuable book deals comprehensively with all aspects of frames, springs, axles, wheels, tyres, drives, steering gear, brakes, universal joints and differential gears. 8½″×5″. 616 pp. 400 illustrations. 75s. net. By post 76s. 6d.

Torque Converters or Transmissions

5th Edition.

Describes the principles and operation of all modern American types of automobile clutches and gearboxes. Friction, automatic, hydraulic and electric clutches are dealt with, and the chapters on power transmissions include electric, hydrostatic, hydro-kinetic, automatic and pneumatic systems. 8½″×5″. 476 pp. 285 illustrations. 65s. net. By post 66s. 6d.

High-Speed Combustion Engines

16th Edition.

First published in 1912, this well-known standard textbook covers American practice in the most comprehensive manner. All aspects of the subject are covered in great detail, including the design, production and testing of all types of petrol engines. Profusely illustrated, this book is a complete treatise on current American practice. 8½″ × 5″. 776 pp. 521 illustrations. 100s. net. By post 101s. 6d.

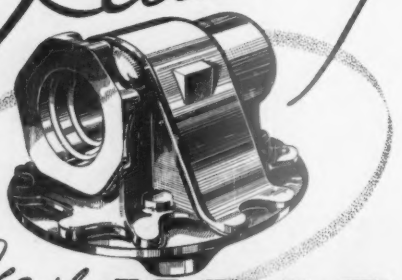
High-Speed Diesel Engines

7th Edition.

For Automotive, Marine, Railroad and Industrial Use. A guide to American practice in diesel engines of the automotive type. Design, fuels and fuel injection equipment, supercharging, lubrication, operation and maintenance are among the subjects dealt with, and there is also a chapter on gas turbines. 8½″ × 5″. 472 pp. 288 illustrations. 60s. net. By post 61s. 6d.

From leading booksellers or direct from:—
ILIFFE AND SONS LIMITED - DORSET HOUSE - STAMFORD ST., LONDON, S.E.1

• IF YOU MUST HAVE *Reliability*



Specify HALE *Finest blackheart* MALLEABLE IRON CASTINGS

SEND FOR DETAILS OF OUR FILM "MODERN MALLEABLE"

HALE & HALE (TIPTON) LIMITED DUDLEY PORT Staffs

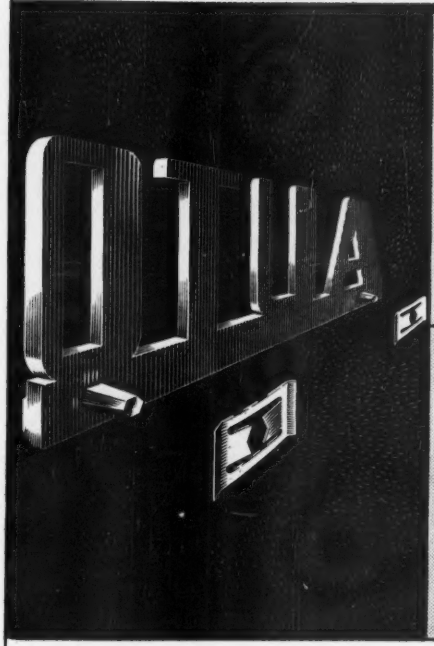
But press operators need Udal protection

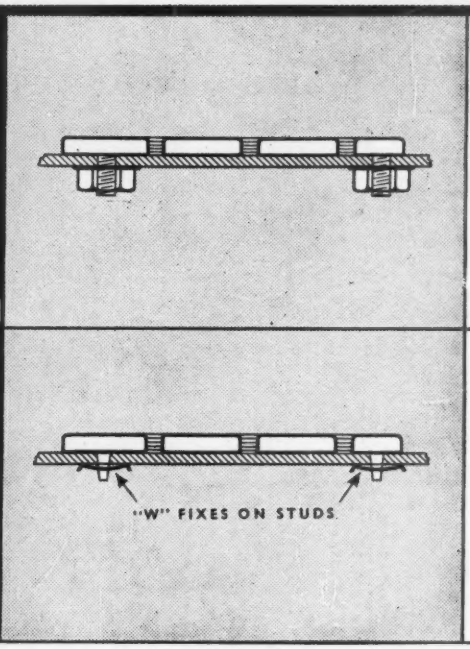
A piece-work operator whose output is reduced by slow guard operation is a frustrated person, and a frustrated person is in constant danger. For greater safety and more production you should ask UDAL about the famous 'Fastrip' synchronized guards, worked by compressed air and timed to a split second. Details will gladly be sent on request.

J. P. UDAL LIMITED
INTERLOCK WORKS
COURT ROAD · BIRMINGHAM 12
Telephone: CALthorp. 3114

Udal PRESS GUARDS

The logical advance in **Retaining**





OLD WAY

Threaded studs were spot welded (or inserted if die-cast) to the name-plate. To hold this in position, washers and nuts were laboriously assembled with great difficulty especially on blind applications.

THE SALTER WAY

Studs are cast in with the nameplate, and the Fixes are simply pushed on, even on blind applications. The whole is firmly retained with an even spring tension.

save material–reduce assembly time–cut costs

When it's a question of assembling components in any engineering field, Salter Retainers are the answer. They replace nuts and bolts, screws, cotter pins, and eliminate expensive threading and machining operations. A large standard range is at your immediate disposal, and we should welcome the opportunity to assist in developing special retainers to solve your problems.

Send for the Salter Retainer catalogue — no designer is complete without it.

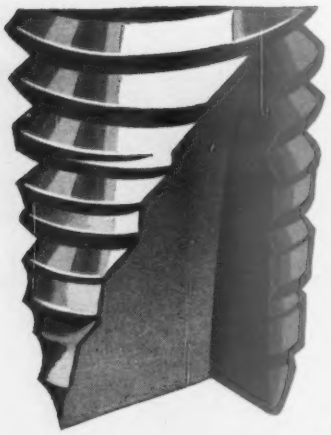
NEATER – MORE POSITIVE – PERMANENT RETAINING

SALTER "TRU'ARC"

Circlips · Fasteners · Retainers · Fixes

Geo. Salter & Co. Ltd., West Bromwich · Spring Specialists since 1760

M-W.446



WHY A SLOTTED SHANK?

The slot exposes a sharp, serrated cutting edge, enabling 'Shakeproof' screws to cut their own thread with a true tapping action. Assembly costs are reduced because of the elimination of a separate tapping operation, and the self-cut threads mate accurately to ensure a vibration resisting fit. 'Shakeproof' thread cutting screws are available for use in hard metals, ordinary metals and plastics. They give greater efficiency, with savings in time and cost.

A.I.D. APPROVED

"SHAKEPROOF"

REG. TRADE MARK Nos. B611535

THREAD CUTTING SCREWS

British Patents Nos. 386895 · 551478

BARBER & COLMAN LTD

MARSLAND RD · BROOKLANDS · MANCHESTER

TELEPHONE: SALE 2277 (4 lines)
TELEGRAMS: "BARCOL" SALE.

SHAKEPROOF PRODUCTS

Dealers and Factors enquiries to the following appointed "SHAKEPROOF" stockists:

George Boyd & Co. Ltd. 229 Buchanan Street, Glasgow C.1.
Brown Bros. Ltd. (all Branches)
Wm. Galloway & Co. Ltd. Blaydon-on-Tyne.
F. Miller & Co. (London) Ltd. Rectory Road, Acton, London W.3.
Nettlefold & Moser Ltd. (all Branches)
Nobby Distributors Ltd. 438 Harrow Road, London W.9.
Wordrew Ltd. 173 Princess Street, Manchester, 1.

SB3

LET *US* SPEED YOUR PROTOTYPES

Makers of Speedy Tooling for all types

EXPERIMENTAL WORK, PATTERNS, MODELS, JIGS, FORM TOOLS

IN ALL MATERIALS TO FACILITATE QUICK TURN ROUND WITH ECONOMY

★ **DESIGNING**
★ **KELLERING**
★ **TOOL MAKING**
★ **CASTINGS**

FOR MORE PERMANENT SCHEMES

Many years of experience with leading Aircraft and Automobile Manufacturers in this type of work

FINCH, WATSON LTD.
GREENGATES
ACCRINGTON
LANCS.
Tel: Accrington 5238 (2 lines)

Wire THREAD INSERTS

MAKE STRONGER THREADS UNDER ANY CONDITIONS IN ANY MATERIAL WHETHER FOR NEW DESIGNS OR SALVAGE

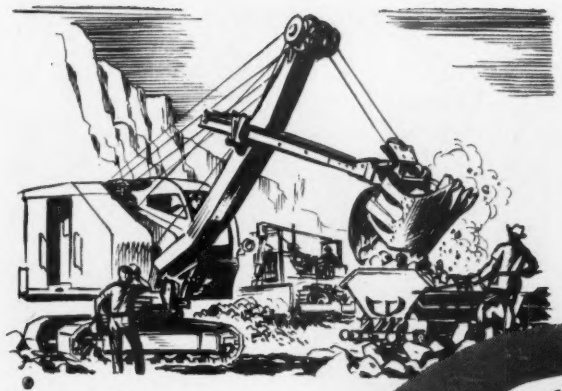
HARD TOUGH THREADS IN SOFT METALS

NEW THREADS FOR OLD

CROSS MANUFACTURING CO. (1938) LTD.

BATH, SOMERSET

Telephone: COMBE DOWN 2355/8 *Telegrams:* CIRCLE, BATH



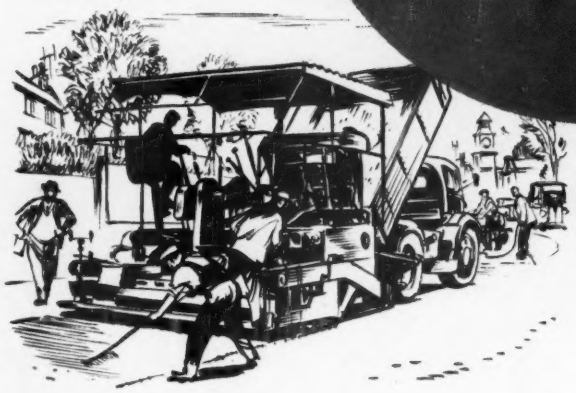
Contractors Plant

Rails and Sidings

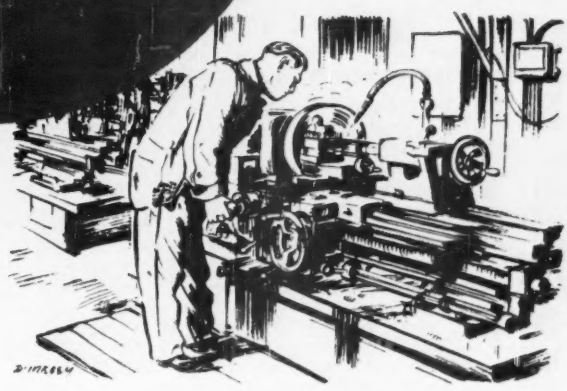
TWW

Wherever you see this sign it means *big* business

Road Surfacing



Machine Tools



IRON & STEEL · NON-FERROUS METALS · TRACTORS & EARTH MOVING PLANT · EXCAVATORS & CRANES RAILS & SIDINGS · SHIPBREAKING · FOUNDRY PLANT & SUPPLIES · CONTRACTORS' PLANT & EQUIPMENT PLANT & MACHINERY · STRUCTURAL STEELWORK FACTORY PLANNING & INSTALLATION

INDUSTRIAL PLANT · INDUSTRIAL DISMANTLING MACHINE TOOLS · ROADSTONE & ROAD SURFACING GRANITE & FREESTONE · PACKINGS & JOINTINGS WIRE & WIRE PRODUCTS · INSULATING MATERIALS NUTS & BOLTS · RUBBER PRESSINGS & PRODUCTS CEMENT · FOOD PREPARING MACHINERY

SERVING INDUSTRY AROUND THE WORLD

THOS. W. WARD LTD

GP/84

Head Office: ALBION WORKS · SHEFFIELD *London Office:* BRETTENHAM HOUSE · LANCASTER PLACE · STRAND W.C.2

What fine reproduction!

TURQUOISE OF COURSE!

Turquoise pencils are famous for:—

SMOOTHNESS Millions more tiny graphite particles are compacted into every length of Turquoise lead. This gives perfect silky smoothness without flaws and means swift, effortless work, saves time and energy.

BLACKNESS Lines drawn with a Turquoise are always crisp and uniformly black due to wonderful 100% Electronic Graphite which guarantees maximum density.

STRENGTH The compact lead that results from this 100% Electronic Graphite will take a needle point and hold it under great pressure. Saves annoyance and frequent sharpenings.

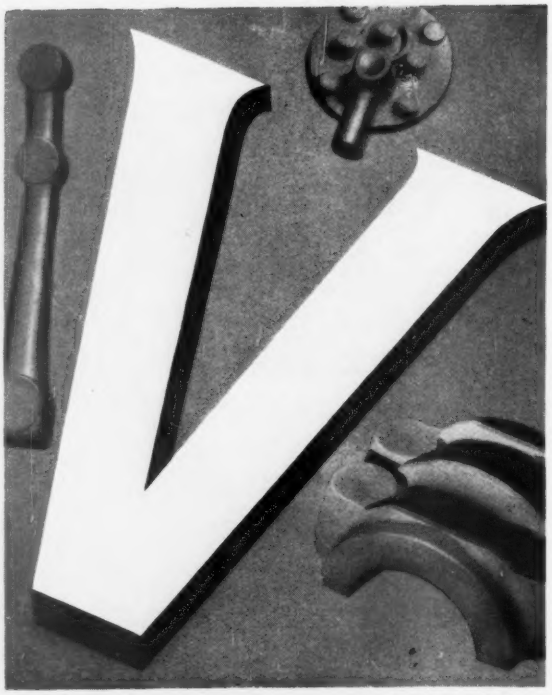
DURABILITY Turquoise lead is so compact that the longest line remains uniform in width and blackness yet will rub out without trace if required.

GRADING Turquoise pencils are available in 17 grades—from 9H to 6B—reliably and uniformly graded and thoroughly checked.

TURQUOISE
drawing pencils

T20

EAGLE PENCIL COMPANY · ASHLEY RD · TOTTENHAM · N.17



MITRE Precision Drop Forgings are preferred by leaders in the Automobile Industry.

A. J. VAUGHAN & CO. (MITRE WORKS) **LTD.**
Wolverhampton Road, WILLENHALL, Staffs. Phone: 486/7

REDUCE *Your* CLEANING COSTS...

***With* HERMETIC MUD FLAPS**

BEADED ON THREE SIDES. REINFORCED WITH 2 PLIES OF CANVAS THROUGHOUT, GIVING GREATER STRENGTH AND LONGER LIFE.

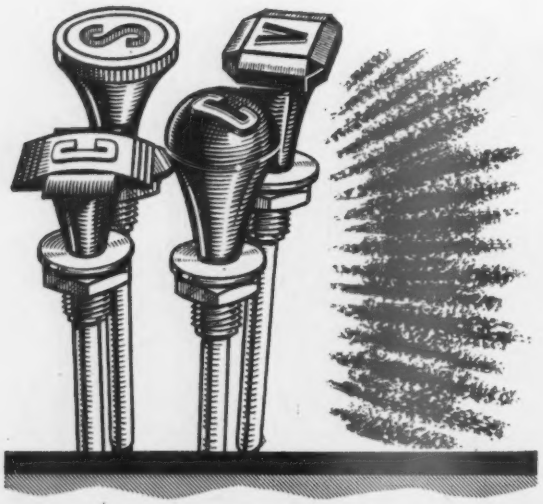
HERMETIC RUBBER CO. LTD.
HERMETIC WORKS · RYLAND ST · BIRMINGHAM 16
PHONE · EDGBASTON 0983/4 *Established 1895* GRAMS · HERMETIC.BIRMINGHAM

Unique

"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

C. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N



Remote Control

for

THROTTLE
STARTER
BONNET
& CHOKE

Gill's Remote Control Cables are known the world over for long life and dependability. They are made from top-quality steel and are guaranteed rustproof.

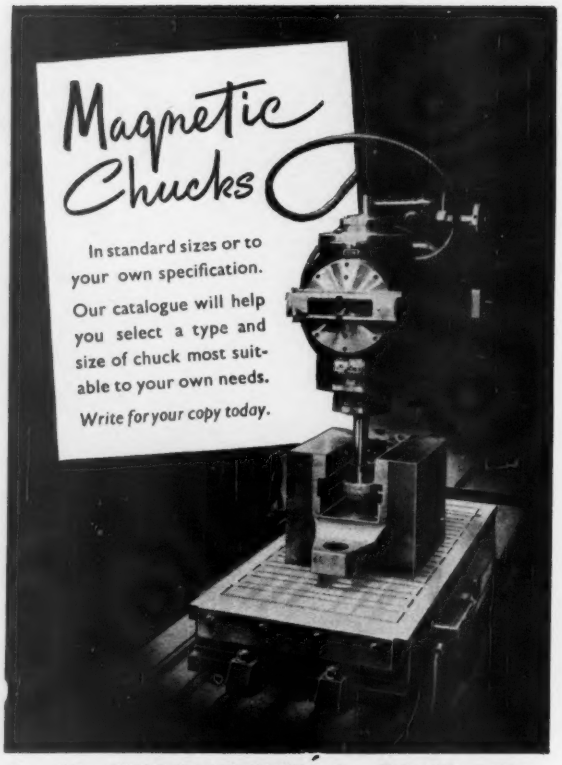
GILL'S

CABLES LTD

PACKINGTON HALL WORKS, LICHFIELD, STAFFORDSHIRE

Telephone: Whittington 284 & 285.
Telegrams "Remote," Lichfield.

A complete Gill's Control Unit has immense strength and under normal working conditions there is never any danger of the inner control member of the cable section pulling out from the steel insert of the knob itself.


Magnetic Chucks
In standard sizes or to your own specification.
Our catalogue will help you select a type and size of chuck most suitable to your own needs.
Write for your copy today.

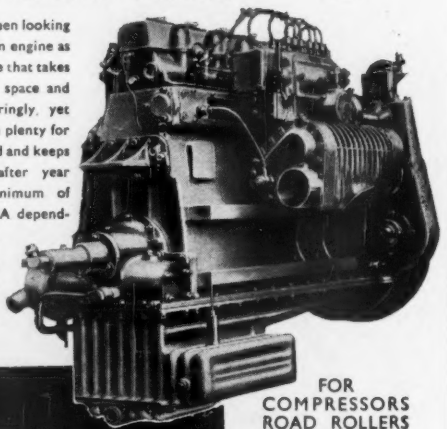
J. H. HUMPHREYS & SONS LTD.
Blackriding Electrical Works, Wenerth, Oldham
'Phone : MAIn 6067

HERE'S THE

Reliability

INDUSTRY DEMANDS

Industry has been looking for just such an engine as this—an engine that takes up very little space and uses fuel sparingly, yet gives power in plenty for the job on hand and keeps going year after year with the minimum of maintenance. A dependable, versatile, hard working, economical engine.



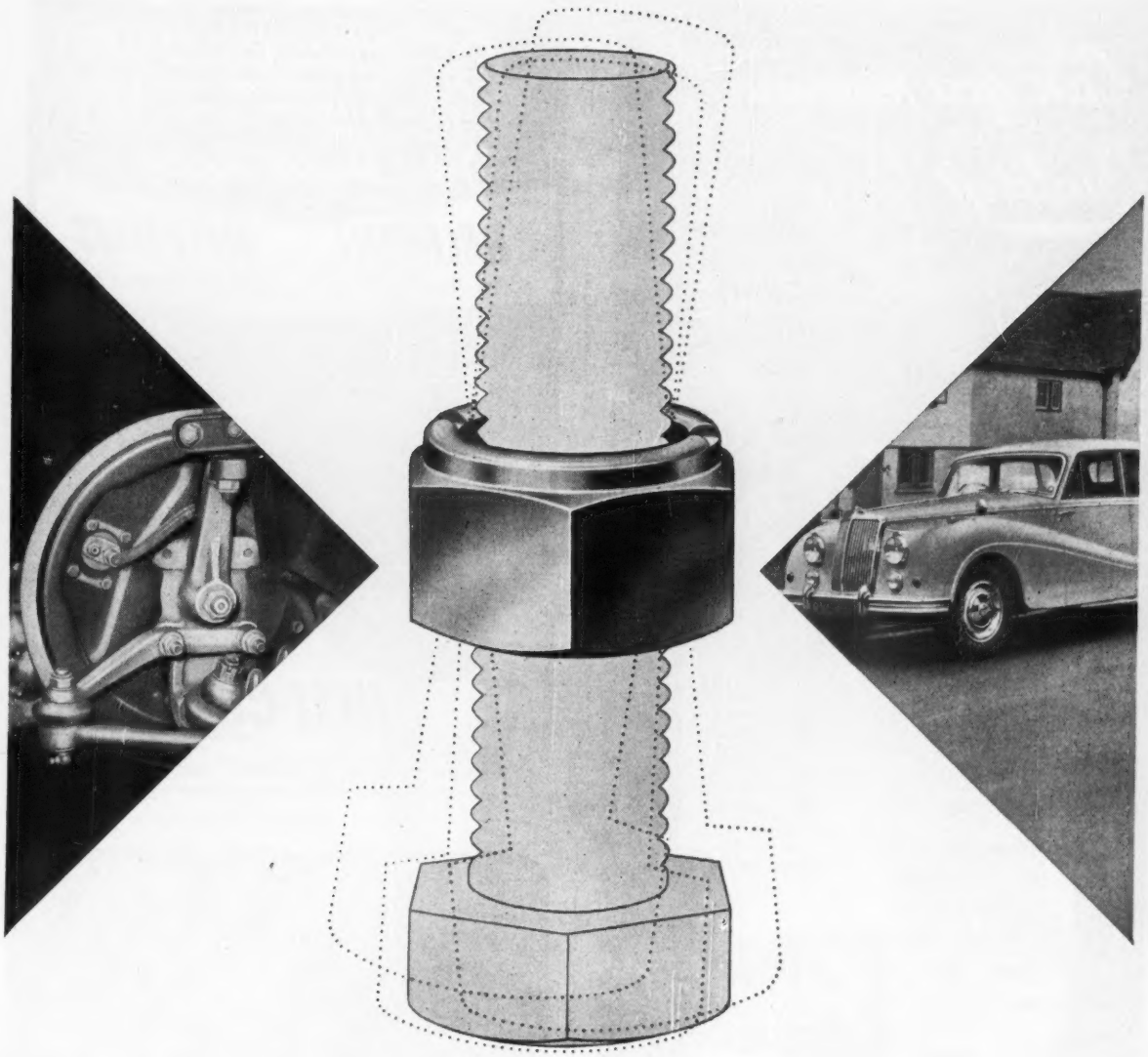
Fodens FD

4, 6 & 12 CYLINDER
2 STROKE OIL ENGINES
50/240 B.H.P.

FOR
COMPRESSORS
ROAD ROLLERS
RAIL SHUNTERS
STATIONARY
ENGINES

Send for details to—
ENGINE DIVISION
FODENS LIMITED
SANDBACH · CHESHIRE

Champions of their weight & class



Nothing rattles the Nyloc

Tough nuts, these Nylocs! Jerk them, jolt them,
shake them, soak them—nothing makes them budge a thous.
Nylocs are fitted on the Armstrong Siddeley Sapphire wherever a
tight hold's needed—throughout the front and rear suspensions and
on the engine mountings, transmission couplings and road wheel attachments.
Pinnacle nuts keep an equally firm grip on the main bearing caps.
Simmonds self-locking nuts are doing a non-rattling good job on
this famous car, and speeding things up on the assembly line too.
The Nyloc, Fibre nut and all-metal Pinnacle nut make
a pretty stubborn trio—and each has its special uses.
Drop us a line and we'll advise you which nut is best for *your* job.

SIMMONDS AEROCESSORIES LIMITED
TREFOREST · PONTYPRIDD · GLAMORGAN
A MEMBER OF THE FIRTH CLEVELAND GROUP

Branches: London, Birmingham, Manchester, Glasgow, Stockholm, Copenhagen, Ballarat, Sydney, Johannesburg, Amsterdam, Milan and New York.

CRC 29N

Can you measure Quality?

'MERLIN'

'KESTREL'

The reputation for reliability over a long period is the best measure of the true quality of GARRINGTONS Hand Tools. It is also the reason why they are confidently chosen by engineers and handymen everywhere.

Obtainable from all recognised Tool and Motor Accessory Stockists.

Write for lists.

Garringtons HAND TOOLS

'JAY'

'MAGPIE'

A MEMBER OF THE GKN GROUP OF COMPANIES

GARRINGTONS LIMITED

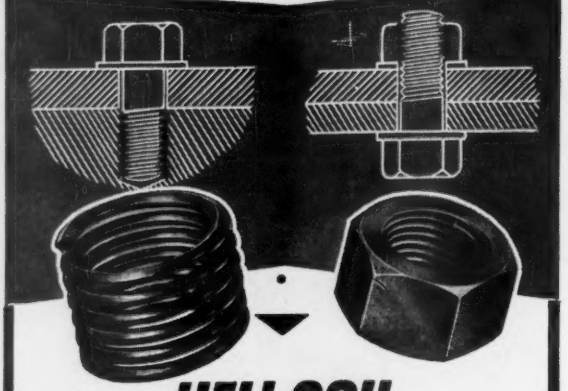
DARLASTON, STAFFS. and BROMSGROVE, WORCS.

For INCREASED DESIGN SCOPE, USE OF LIGHTER SECTION MATERIAL, HEAVY DUTY ASSEMBLY, FREEDOM FROM WEAR, CORROSION, STRIPPING & MOST OTHER THREAD TROUBLES . . .

You must have . . .

HELI-COIL . HELI-NUT

SCREW THREAD INSERTS . HIGH ENDURANCE NUTS

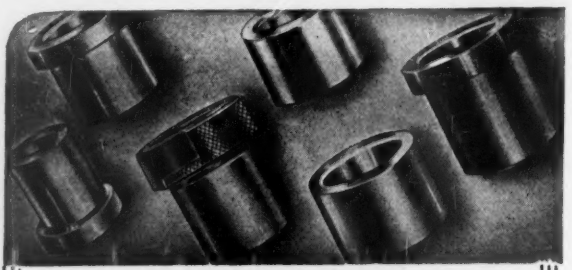


HELI-COIL

REG'D TRADE MARK

Manufactured by:

ARMSTRONG PATENTS CO. LTD · EASTGATE · BEVERLEY · YORKSHIRE



THE BUSH PEOPLE for NITRIDED JIG BUSHES and LINERS

NEW CATALOGUE AVAILABLE ON REQUEST

These jig bushes and liners are manufactured in accordance with B.S.S. 1098:1953 the recommended sizes for the jig plate holes being in accordance with British Standard for fit limits (B.S.S. 164:1941).

Established 30 years

LAWRENCE Bros. MILLWARD LTD.

TELEPHONE WICKERSLEY 2041-2

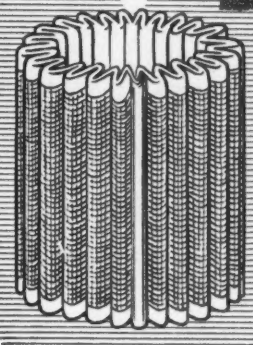
ROTHERHAM

THE FIRST FEW MINUTES

Does *filtered* or *unfiltered* oil reach the engine during the first few minutes after starting from cold. That is the vital question when considering the choice of filters—for this is the time when excessive wear can easily be caused.

Vokes Filters, with their high quality felt fabric elements offer such low resistance that the direct flow device comes into operation for the absolute minimum of time. Yet, despite this low resistance, the highest standards of filtration are ensured at all times. Moreover, the unique design and flow principles of the Vokes filter ensure that no recirculation of trapped sludge can take place when the direct flow device is in operation, even under extreme conditions of service.

For the sake of the first few minutes . . . and of the years of service that follow, specify Vokes filters.



VOKES

pioneers of scientific filtration

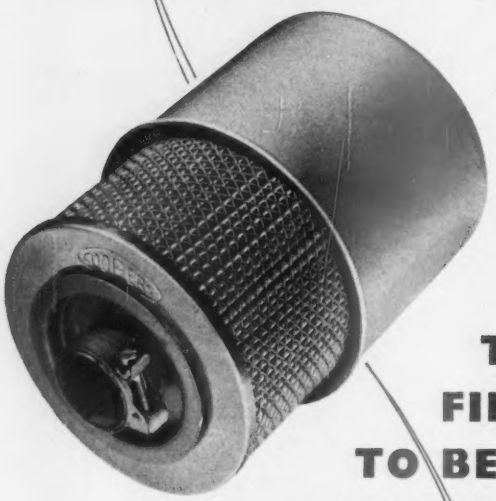
VOKES LTD. Head Office: GUILDFORD, SURREY London Office: 123, Victoria Street, Westminster, S.W.1.

Telephone: Guildford 62861 (6 lines). *Telegrams and Cables: Vokesacess, Guildford, Telex.* *Telex: 13-535 Vokesacess.*

Vokes (Canada) Ltd., Toronto. *Represented throughout the world.* Vokes Australia Pty. Ltd., Sydney.

V134

PAPER ELEMENT AIR CLEANERS



THE FIRST TO BE IN QUANTITY PRODUCTION IN THIS COUNTRY

- POSITIVE FILTRATION WITH MAXIMUM EFFICIENCY *AT ALL ENGINE SPEEDS*
- CONFORM TO B.S.S. 1701
- NO OIL TO PULL OVER
- CAN BE MOUNTED IN ANY PLANE

THE COOPER PAPER ELEMENT AIR CLEANER is lighter than the orthodox type. It is simple to dismantle and is easily cleaned by reverse air flow.

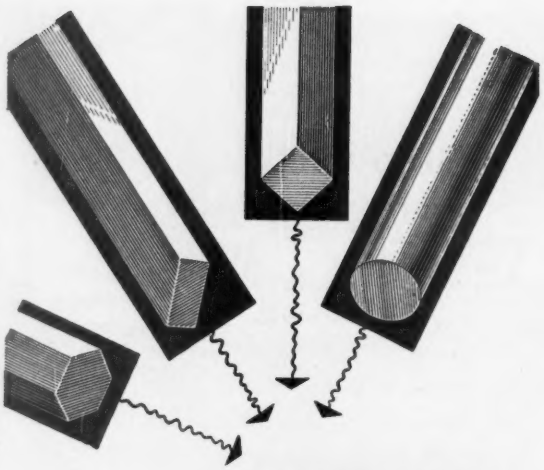
Coopers' Technical Staff are available always for consultation.

Further details will be supplied on request to . . .

COOPERS

MECHANICAL JOINTS LIMITED

LLANFOIST WORKS, ABERGAVENNY, MON. Tel. Abergavenny 550



quality in special purpose steel

Dunelt

ALLOY AND SPECIAL CARBON STEELS

Black rolled, bright drawn or smooth ground, in heat-treated or unheated conditions. Free cutting steels, heat-resisting steels, die steels, shear blade steels, high-speed tool steels, stainless steels, valve steels, hollow steel bars.

DUNFORD & ELLIOTT (SHEFFIELD) LTD.
Attercliffe Wharf Works, Sheffield 9.
Telephone: 41121 (5 lines). *Telegrams:* "Blooms, Sheffield, 9".
London Office: Linford Street, S.W.8.
Birmingham Office: 25 Burlington Chambers, 118, New St., 2

Special Purpose Machines

FAIRMAN PRECISION TOOLS AND PRODUCTS LIMITED

PRESS TOOLS
PROTOTYPES
MOULDS
GAUGES
JIGS, ETC.

'Phone : **3678**

STATION RD (EAST), HORLEY, SURREY

A.I.D., M.O.S. AND ADMIRALTY APPROVED

GLOUCESTER

malleable & grey iron castings

TOUGH AND RIGID YET EASY TO MACHINE

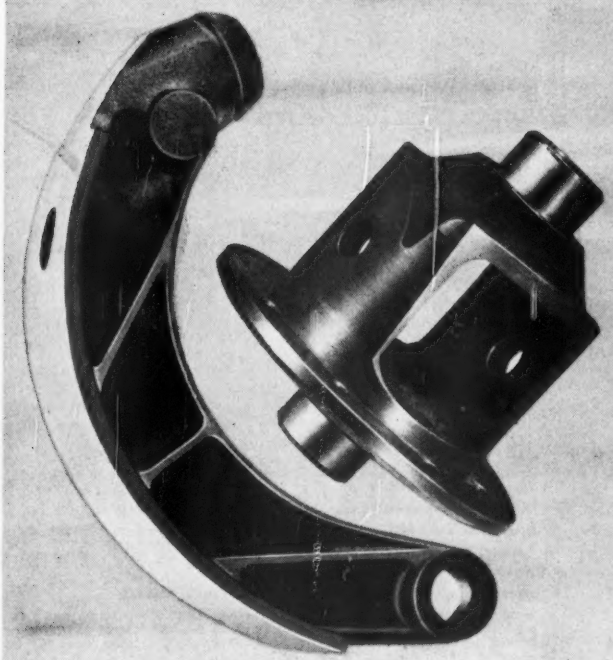
Gloucester Blackheart Malleable castings are widely used throughout the automobile, railway and farm machinery industries.

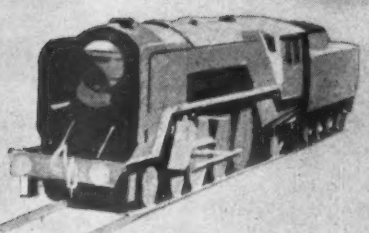
The new elevator-type electric furnace anneals in 48 hours! – instead of the usual 7 days. It also allows greater control of the component during annealing, resulting in uniformity of metal, greater strength and resistance to impact, and a smoother, finer skin. Machining time is therefore reduced to a minimum. Every heat is under constant laboratory control throughout the day and castings are rigidly inspected at every stage of production.

Gloucester technicians will gladly advise on the design of malleable or grey iron castings. Why not call them in at the drawing board stage?

Typical Gloucester Malleable specifications are:

Gloucester Blackheart Malleable		*Gloucester Lamellar Pearlitic Malleable*	
Elongation	18%	Elongation	5%
Yield Point	15 tons	Yield Point	22 tons
Tensile strength	25 tons p.s.i.	Tensile strength	35 tons p.s.i.





(right) Differential cage for motor vehicle in Malleable Iron.
(left) Brake Shoe in Malleable Iron.

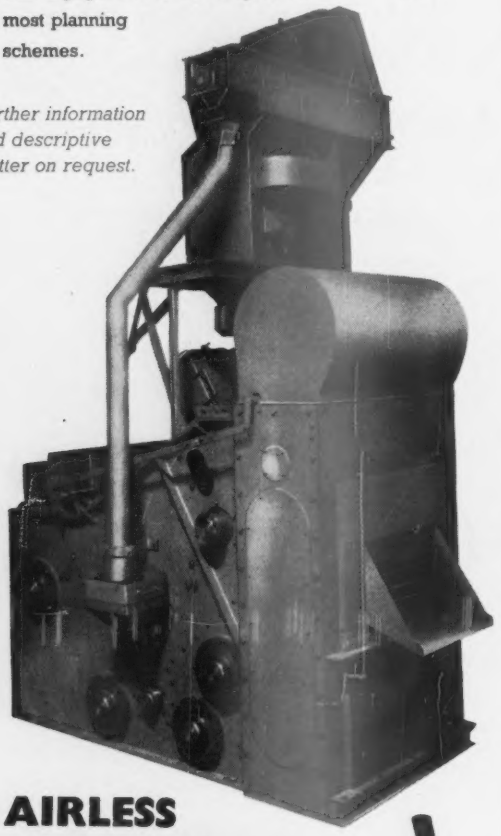
GLOUCESTER FOUNDRY LTD., EMLYN WORKS, GLOUCESTER
(A subsidiary of the Gloucester Railway Carriage & Wagon Co. Ltd.)

Telegrams: 'Pulleys' Gloucester
Telephone: Gloucester 23041

The CENTRIBLAST Automat

inserted in your production line will produce cleaned parts automatically, either in batches, or as single units and its automatic load measure together with auto feed and discharge enable this equipment to be adopted in most planning schemes.

Further information and descriptive matter on request.



AIRLESS CONTINUOUS BLAST CLEANING MACHINE

SPENCER & HALSTEAD LTD.

BRIDGE WORKS · OSSETT · YORKSHIRE

TEL OSSETT 821-4 GRAMS SPENSTEAD

P4875

BEST IN EACH CLASS

Wrenches and Socket Sets in high grade Chrome Alloy Steel to suit English, American, Unified and and Metric sizes. Sockets in ·448" hexagon, $\frac{1}{4}$", $\frac{9}{32}$", $\frac{3}{8}$", $\frac{1}{2}$", $\frac{3}{4}$" & 1" Square Drives.

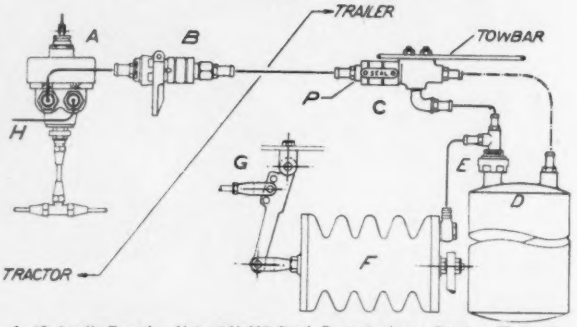
Fully illustrated catalogue available on request.

TOOL UP WITH CHROME ALLOY STEEL BRITOOL SERVICE TOOLS

JENKS BROTHERS LIMITED, BRITOOL WORKS, BUSHBURY, WOLVERHAMPTON.

F&J

SINGLE LINE PROGRESSIVE BREAKAWAY SYSTEM



A. Hydraulic Reaction Valve LV 207 Dual Control, shown fitted to Hydraulic Pipe Line on Tractor.

B. "C" type Coupling with Auto. Shut-off Valve, attached to rear of Tractor.

C. Breakaway Valve SBS. 256 (or SBS. 257) attached to Tow Bar of Trailer.

D. Vacuum Tank on Trailer.

E. Non-return Valve.

F. Power Unit on Trailer operating linkage **G** to Trailer Brakes.

H. Hose connecting LV 207 to source of Vacuum. Hose connections shown as solid lines are those used in normal operation of Brakes. The Hose shown in broken line connects the Vacuum Tank to the Power Unit when Valve "C" is operated in emergency.

P. Plunger with Safety Seal.

Existing Trailer can be converted by adding "C," "D" and "E."

FEENY & JOHNSON LTD

134-136, Ealing Road, Wembley, Middlesex

Tel: WEMbley 4801 & 4802 *Grams:* Feejohn, Wembley

DHB/2008B

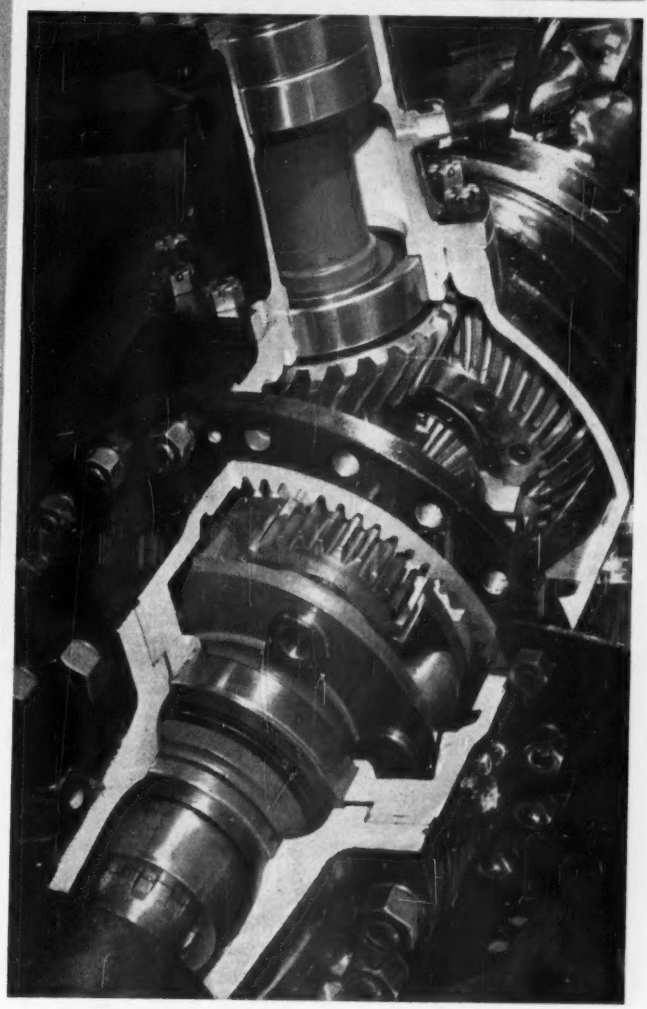
when the going is tough . . . .

DROP FORGINGS

by

FIRTH-DERIHON

SHEFFIELD & DARLEY DALE



Heavy duty axle
Scammell
Lorries Ltd.

THE FIRTH-DERIHON STAMPINGS LIMITED, SHEFFIELD.

POWER by POWER JACKS

★ **HYDRAULIC PUMPS of proved efficiency for hand or power operation**

A MEMBER OF THE NEWTON GROUP

TECHNICAL DATA

Normal operating pressure . . 1,500 lbs. sq. in.

Maximum operating pressure (Blow off) . . 2,500 lbs. sq. in. (*or to specification*)

Output complete stroke . . . . . ·825 cu. ins.

Effective piston area . . . . . ·600 ins.

Handle leverage ratio 16-1

Alternative fluid capacities in pints . 2¾ pts., 6 pts., 16 pts., 24 pts., 32 pts.

Larger capacities to special order.

Vertical or horizontal pump handle.

JACKS from 1 TON to 5 TONS in a variety of stroke lengths

Send for illustrated technical brochure Publication No. H/223

POWER JACKS LIMITED

VALETTA RD. · ACTON · LONDON · W.3

TEL: SHEPHERDS BUSH 3443 (4 lines) · GRAMS: NEWSORBER, EALUX, LONDON

1109

'LONDON' BRAND
TINNED & LEADCOATED STEEL SHEETS
for the automobile industry
Superior ductility and excellent working-up qualities — supplemented by durability, affinity for solder and resistance to corrosion —make 'London' Brand Tinned and Leadcoated Steel Sheets specially suited to the production of numerous automobile components. Available in a wide range of sizes. Obtainable through your usual merchant or stockholder.
SPECIFY 'LONDON' BRAND BY NAME
Send now for Brochure
SHIMWELL & Co LTD
MANUFACTURERS SINCE 1875
WELLINGTON ROAD · LEYTON · LONDON · E.10
Tel: LEYtonstone 2281-2

S23

There's gold in them thar hills . . . if you know where to find it. If you don't mind leaving your wife and children for seven years at a stretch, getting a bullet through the lobe of your ear, nearly dying of thirst and finally dying of heart-break. There's gold . . .

But wait. Many manufacturers use solvents in the course of their process. Volatile solvents, *expensive* solvents. And for some reason we can't quite understand they let them float away into the atmosphere. Why, dang it **There's Gold in the air!** for the man who hears about Active Carbon and Solvent Recovery, and hollers for

SUTCLIFFE SPEAKMAN

AND COMPANY LIMITED, LEIGH, LANCASHIRE. TEL: LEIGH 94.
LONDON OFFICE: 2 CAXTON ST., WESTMINSTER, S.W.1. TEL: ABBEY 3085

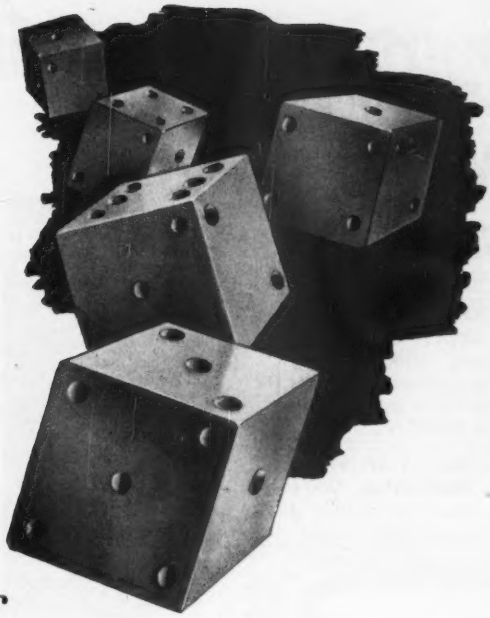
no

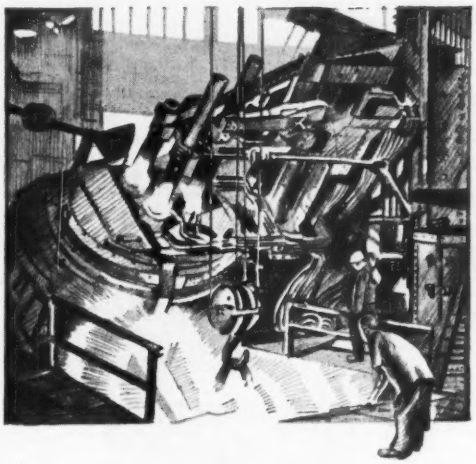
place

for

chance

in the manufacture of





OSBORN

OSBORN FINE STEELS

Tool steels, stainless steels, heat-resisting steels, manganese steels and a wide range of alloy steels are produced by Samuel Osborn & Co., Limited. The reputation of these steels, including the well-known brands of *Hand & Heart, Titanic, Mushet, Tropic and Titan*, depends upon their quality and their quality depends upon rigid control in manufacture.

The results of the experience of generations of steelmakers are blended with the latest technical advances in melting practice, to produce steels which will meet the most exacting standards—there's no place for guesswork in the art and science of steelmaking.

FINE STEELMAKERS · STEELFOUNDERS
ENGINEERS' TOOLMAKERS

SAMUEL OSBORN & CO., LIMITED

CLYDE STEEL WORKS · SHEFFIELD · ENGLAND

Six factors to cut running costs

- **HARD CHROME PLATED RING** *for long life & minimum bore wear.*
- **TURNED PERIPHERY RING, GRANODISED SURFACE** *for quick initial bedding to compensate the slower bedding expected with the chrome plated ring.*
- **INTERNALLY STEPPED RING, GRANODISED SURFACE** *a combined oil control and compression ring.*

- **"SEGVENT" OIL CONTROL RINGS :** *a high pressure ring in high grade DTD 485 iron, with a long efficient working life*

- **"FLEXIVENT" OIL CONTROL RING :** *(Reg'd Trade Mark No. 756949) with narrow lands and maximum possible venting for oil drainage. It is more flexible than the orthodox type of oil control ring, enabling the periphery to accommodate a considerable amount of bore wear or distortion.*
  Note the absence of heavy sections between the drain slots.
  Optional, tool finish, granodised or chrome plated.
- **All ring grooves deep anodically treated giving a wear resistant surface equal to a hardness value of 800/900 Brinell.**

This ring pack can be supplied with pistons without anodically treated ring grooves

Specialloid 'LONG-LIFE' PISTONS

ARE RECOMMENDED FOR ENGINES USING LOW VISCOSITY LUBRICATING OILS

SPECIALLOID LTD., BLACK BULL ST., LEEDS, 10. Tel. Leeds 31471/7

CALIBRATED JETS

Amal Limited make jet-calibrating machines for checking carburetter petrol jets to conform to British Standard No. 720 of 1948. Amal Limited are equipped to manufacture and calibrate jets from .005" to .5" dia. — all of which discharge a specified flow to within close limits under specified conditions. 'Amal' calibrated jets find many applications for metering the flow of other non-viscous liquids, and also of gases such as town gas, butane, propane, methane, etc.

AMAL

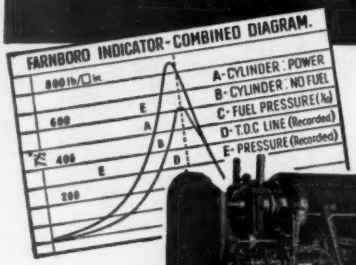
Service to the Motor and other Industries

AMAL LTD., WITTON, BIRMINGHAM, 6

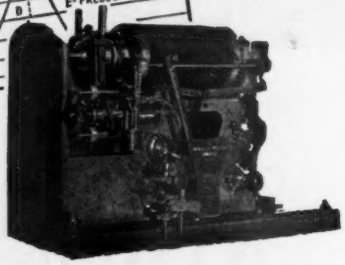
A/157

DOBBIE McINNES

'FARNBORO' ELECTRIC INDICATOR



Large Diagrams up to $14\frac{1}{2}" \times 7\frac{1}{2}"$



No complex electric circuits. Replacements are negligible. No glass components. Simplicity ensures ready understanding and manipulation without special knowledge. Very large diagrams. No Photography, thus saving time and trouble. Calibration Lines can be recorded while taking diagrams.

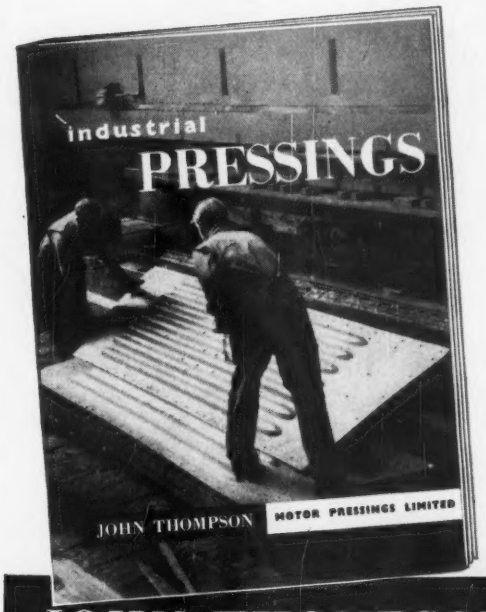
DOBBIE McINNES LTD.

Nautical and Engineering Instruments

BROOMLOAN ROAD, GLASGOW, S.W.1

Also at South Shields · Liverpool · London

a modern manufacturing science



The necessary plant and long experience in heavy precision pressings are available in the John Thompson organisation for the production of all types of frames, components and fabrications for trucks, buses and heavy transport of all kinds. Preliminary discussion with experienced design engineers is freely offered. Write for illustrated brochure.

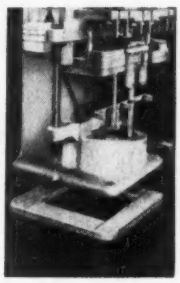
JOHN THOMPSON MOTOR PRESSINGS LTD. BEACON WORKS, WOLVERHAMPTON
Telephone : BILSTON 41121
Telegrams : MOTOFRAME, WOLVERHAMPTON

JOHN THOMPSON | **MOTOR PRESSINGS LIMITED**

CROID 65
MACHINE FIXING GLUE
COOPERS FELT

HOW CAN THEY EXPECT GOOD WORK WITH THIS NOISE AND VIBRATION?

Vibration doesn't only wear out workers, it wears out machines, too. Luckily, there's Croid-Cooper nowadays. With the Croid-Cooper method you stick your machines down like a stamp—but a stamp with a holding power of 50 lb. to the square inch—move them when you like, do away with bolting, grouting, damaged floors. And the Croid-Cooper method can absorb more than 80% of vertical vibration on some machines. Send for details today.



COOPER & CO. (BIRMINGHAM) LTD., BRYNMAWR, BRECONSHIRE.
Telephone : BRYNMAWR 312

MINIRACK

Oscillographs

ME 122 ENGINE INDICATOR

This modern cathode-ray Engine Indicator, manufactured by the Oscillograph Division of Southern Instruments Ltd., solves engineering and industrial problems by measuring Transient Pressure, Force, Strain, Vibration, Acceleration and other physical qualities.

Please write for further details.

SOUTHERN INSTRUMENTS OSCILLOGRAPH DIVISION

Proprietor: Southern Instruments Ltd.
CAMBERLEY, SURREY
Telephone No: Camberley 2230 (3 lines).
Telegraphic Address: Minrak, Camberley, England.

MEKELITE

GEARED JOINT
INDUSTRIAL LIGHTING UNITS

For wall, bench or machine mounting. *Catalogue sent free on request*

MEK-ELEK Engineering Ltd. MITcham 3072
17, Western Road MITCHAM, Surrey.

the motor vehicle

fifth edition

By K. Newton, MC, BSc, ACGI, AMinstCE, MIMechE and W. Steeds, OBE, BSc, ACGI, MIMechE. This book covers recent advances in automobile design, including engines, transmissions, axles, brakes, steering, suspension and chassis details. Both petrol and diesel engines are covered and the present state of the gas turbine as applied to road vehicles is considered. Non-technical language is used, the book providing an accurate straightforward explanation of automobile engineering theory.

from all booksellers 42s net by post 43s 6d

Iliffe & Sons Ltd., Dorset House, Stamford St., London, S.E.1

(5)

3M COATED ABRASIVES

SPEED THE GRINDING OF THE TOUGHEST WELDS—

Part of the 3M Grinding and Polishing System developed to speed modern production technique.

SEEING IS BELIEVING. Only 3M provide grinding and polishing Demonstration Centres run by qualified engineers. Here, at no cost and on your own products, you can see for yourself how time can be saved and a better finish achieved. Remember, 3M abrasives do a better job.

3M COMPANY

MINNESOTA MINING & MANUFACTURING CO. LTD.
London · Birmingham · Manchester · Glasgow

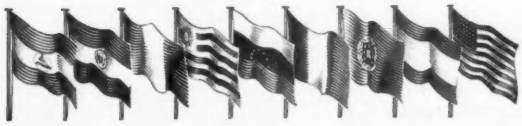
More than a change of address

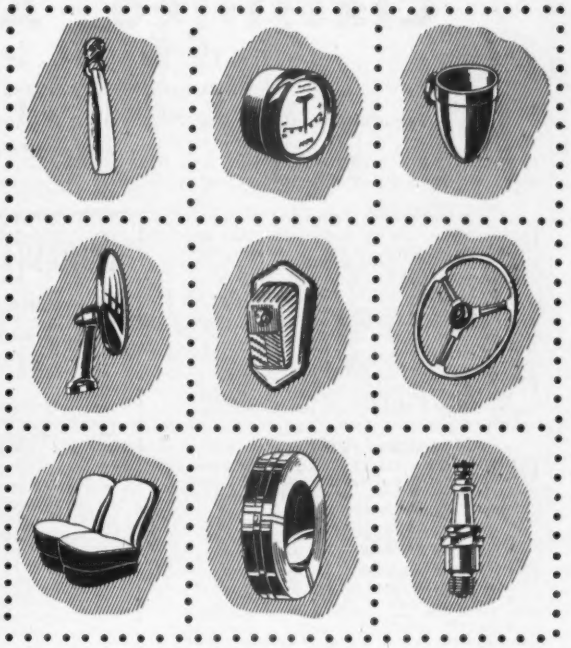
40-66 QUEEN VICTORIA STREET, LONDON, E.C.4

This fine building, to which the Bank moved from Tokenhouse Yard on 27th May, 1957, is a symbol of growth and enterprise not only of the Bank but also of the countries which it serves. The new Headquarters will be an instrument of service to all who have business with Latin America, and will see the continuance of nearly a century of endeavour for British trade.

BANK OF LONDON
& SOUTH AMERICA LIMITED

Branches in Bradford: 55 Well St.
Manchester: 36 Charlotte Street, and in
ARGENTINA · BRAZIL · CHILE · COLOMBIA · ECUADOR
EL SALVADOR · GUATEMALA · NICARAGUA · PARAGUAY
PERU · URUGUAY · VENEZUELA · PORTUGAL · SPAIN
PARIS · NEW YORK · CONTINENTAL REPRESENTATIVE'S
OFFICE: TALACKER 35, ZÜRICH.





Find the car Bumper in this picture

Find the Habershon steel strip and you've found the bumper . . . it's just one of the innumerable applications of this vital material in the automobile industry.

For over a century we have produced hot and cold rolled strip and sheet to the most exacting specifications. Modern high-speed production methods enable us to produce the quantity you need at the quality for which we are famous. We welcome your most exacting specifications.

You can't get away from it

Habershon

STEEL STRIP

means quality in quantity

J. J. Habershon & Sons Ltd., Rotherham. Tel. 2081 (6 lines).

OA/3449

MINIRACK

Oscillographs

ME 122 ENGINE INDICATOR

This modern cathode-ray Engine Indicator, manufactured by the Oscillograph Division of Southern Instruments Ltd., solves engineering and industrial problems by measuring Transient Pressure, Force, Strain, Vibration, Acceleration and other physical qualities.

Please write for further details.

SOUTHERN INSTRUMENTS OSCILLOGRAPH DIVISION

Proprietor: Southern Instruments Ltd.
CAMBERLEY, SURREY
Telephone No: Camberley 2230 (3 lines).
Telegraphic Address: Minrak, Camberley, England.

MEKELITE

GEARED JOINT
INDUSTRIAL LIGHTING UNITS

For wall, bench or machine mounting. *Catalogue sent free on request*

MEK-ELEK Engineering Ltd.
17, Western Road MITCHAM, Surrey. MITcham 3072

the motor vehicle

fifth edition

By K. Newton, MC, BSc, ACGI, AMinstCE, MIMechE and W. Steeds, OBE, BSc, ACGI, MIMechE. This book covers recent advances in automobile design, including engines, transmissions, axles, brakes, steering, suspension and chassis details. Both petrol and diesel engines are covered and the present state of the gas turbine as applied to road vehicles is considered. Non-technical language is used, the book providing an accurate straightforward explanation of automobile engineering theory.

from all booksellers 42s net by post 43s 6d

Iliffe & Sons Ltd., Dorset House, Stamford St., London, S.E.1

(5)

3M COATED ABRASIVES

SPEED THE GRINDING OF THE TOUGHEST WELDS—

Part of the 3M Grinding and Polishing System developed to speed modern production technique.

SEEING IS BELIEVING. Only 3M provide grinding and polishing Demonstration Centres run by qualified engineers. Here, at no cost and on your own products, you can see for yourself how time can be saved and a better finish achieved. Remember, 3M abrasives do a better job.

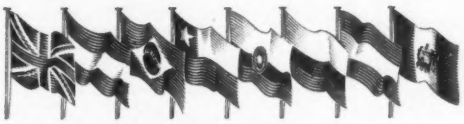
3M COMPANY

MINNESOTA MINING & MANUFACTURING CO. LTD.
London · Birmingham · Manchester · Glasgow

More than a change of address

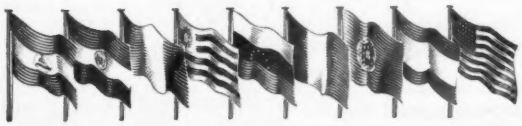
40-66 QUEEN VICTORIA STREET, LONDON, E.C.4

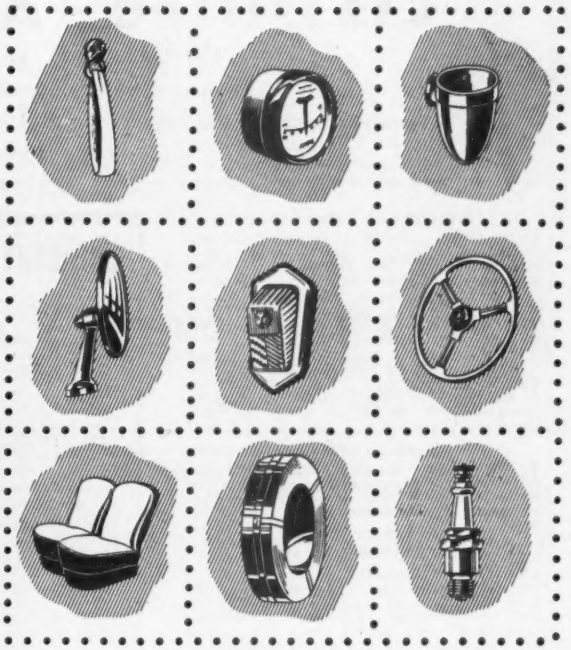
This fine building, to which the Bank moved from Tokenhouse Yard on 27th May, 1957, is a symbol of growth and enterprise not only of the Bank but also of the countries which it serves. The new Headquarters will be an instrument of service to all who have business with Latin America, and will see the continuance of nearly a century of endeavour for British trade.



BANK OF LONDON
& SOUTH AMERICA LIMITED

Branches in Bradford: 55 Well St.
Manchester: 36 Charlotte Street, and in
ARGENTINA · BRAZIL · CHILE · COLOMBIA · ECUADOR
EL SALVADOR · GUATEMALA · NICARAGUA · PARAGUAY
PERU · URUGUAY · VENEZUELA · PORTUGAL · SPAIN
PARIS · NEW YORK · CONTINENTAL REPRESENTATIVE'S
OFFICE: TALACKER 35, ZÜRICH.





Find the car Bumper in this picture

Find the Habershon steel strip and you've found the bumper . . . it's just one of the innumerable applications of this vital material in the automobile industry.

For over a century we have produced hot and cold rolled strip and sheet to the most exacting specifications. Modern high-speed production methods enable us to produce the quantity you need at the quality for which we are famous. We welcome your most exacting specifications.

You can't get away from it

Habershon
STEEL STRIP
means quality in quantity

J. J. Habershon & Sons Ltd., Rotherham. Tel. 2081 (6 lines).
OA/3449

Classified Advertisements

RATE 4d. PER WORD · MINIMUM 4/-

Each paragraph charged separately. Box number 5 words plus 1/-

Advertisements for the July 1957 issue should be to hand not later than first post 25th June.

(No responsibility accepted for errors)

MACHINERY FOR SALE

FOUR Magee No. 10 Automatic Wiring and Edging Machines for sale. Capacity: minimum 24 S.W.G. sheet and 10 S.W.G. wire. Maximum 14 S.W.G. sheet and ¼" wire or 16 S.W.G. sheet and ⅜" wire. Two rates of feed, 6' and 18' per minute. Treadle clutch. Motor drive for 400/3/50. Photo. F. J. Edwards Ltd., 359 Euston Road, London, N.W.1. {5574

PATENTS

PATENT No. 705129, "Fuel Injector," for sale or licence. Apply: Chatwin & Company, Chartered Patent Agents, 253 Gray's Inn Road, London, W.C.1. {5577

SERVICES OFFERED

DESIGN Office Capacity available for Mechanical and Production Engineering. Special Machines and Projects. Norris Brothers Ltd., 53 Victoria Street, London, S.W.1. Tel.: Abbey 5444. {5546

SITUATIONS VACANT

CAR Project Engineer. An assistant project engineer is required by The Rover Co. Ltd., Lode Lane, Solihull. This is an opportunity to work on a new car project and the successful applicant will be offered a salary commensurate with experience. The Company operate a Staff Contributory Pension scheme. Interested applicants are invited to apply in confidence, with full particulars of experience and personal details, to the Labour Manager. {5564

APPLICATIONS are invited for pensionable posts as Examiners in the Patent Office to undertake the official scientific, technical and legal work in connection with Patent applications. AGE at least 21 and under 35 years on 1st January, 1957, with extension for regular Forces' service.

CANDIDATES must have (or obtain in 1957) 1st or 2nd Class Honours in Physics, Organic or Inorganic Chemistry, Mechanical or Electrical Engineering or in Mathematics, or an equivalent qualification, or have achieved a professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. For a limited number of vacancies, candidates with 1st or 2nd Class Honours degrees in other subjects—scientific or otherwise—will be considered. Exceptionally, candidates otherwise qualified by high professional attainments will be considered.

STARTING pay for 5-day week of 42 hours in London between £605 and £1,120 (men), according to post-graduate (or equivalent) experience and National Service. Maximum of scale £1,345. Women's pay above £605 slightly lower, but is being raised to reach equality with men's in 1961. Good prospects of promotion to Senior Examiner, rising to £2,000 (under review), and reasonable expectation of further promotion to Principal Examiner.

APPLICATION form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S 128/57 and stating date of birth.

INTERVIEW Boards will sit at intervals, as required. Early application is advised. {5572

ROOTES Group, Export Division, London, require Engineer, 30-40 years of age, experienced in Motor Vehicle Manufacture and Assembly. Appointment embraces duties in connection with Production Planning; Factory Layout; Equipment Purchase and the commercial aspects of Overseas Production. Attractive salary, working conditions and pension are offered and there is opportunity for advancement and travel. Applications, treated confidentially, including details and photograph, to Secretary, Rootes Ltd., Devonshire House, Piccadilly, W.1. {5578

A REALLY experienced Research and Development Engineer for I.C. engines, capable of design modification for efficiency. Must have full knowledge of Heenan and Froude water brake, also air flow rigs. Responsible to directors of company only. Substantial salary to man with necessary experience. Messrs. Alexander Engineering Co. Ltd., Haddenham, Bucks. Tel.: Haddenham (Bucks) 345-6. {5575

DRAUGHTSMEN required, between 22 and 24 years of age, with general engineering experience in Automobile or Rolling Stock, to train as design engineers on specialized suspension systems. Excellent prospects. Pension Scheme in operation. Situation approximately 20 miles south of London. Apply in writing, stating age, training, general experience and salary expected, to Box Y262, c/o Streets, 110 Old Broad Street, E.C.2. {5576

UNIVERSITY OF BIRMINGHAM

Department of Mechanical Engineering

Graduate School of Thermodynamics and Related Studies.

A course available in the above School provides facilities for the study, at advanced level, of modern developments in Thermodynamics and allied subjects and of their applications in the general field of the heat engine. The normal entrance qualifications are an Honours Degree in Mechanical Engineering together with a minimum of two years of practical experience in industry. On completion of the twelve-months course commencing on 7th October, 1957, and including nine months attendance at the University, successful candidates qualify for the award of the degree of Master of Science. In special circumstances applications may be considered from graduates in other Sciences or non-graduate engineers holding satisfactory alternative qualifications. In the latter case it will usually be necessary for two years to be spent in completing the course. The award to successful non-graduate engineers is the Diploma of Graduate Studies.

The inclusive fee for the course of study is £81 0 0. In certain cases where a student is not sponsored by an employer, the University may consider applications for the remission of the fee and, where essential, for the grant of a maintenance allowance during the period of attendance.

Further particulars and application forms may be obtained from the Registrar, The University, Edgbaston, Birmingham, 15. Applicants are advised to apply before August 1st but applications received after this date may be considered if places are available.

DEVELOPMENT ENGINEER/ CHIEF DRAUGHTSMAN

required for well known International Firm in North-East England.

Applicants should hold A.M.I.Mech.E. or equivalent and should have experience in design of MEDIUM SIZED EARTH MOVING AND MINING EQUIPMENT for Batch Production.

The successful applicant will be responsible to the Managing Director.

Please apply in writing, giving full details, which will be treated in confidence, to Managing Director, Box 8118.

COTTON BAGS

FOR SPARE PARTS Etc.

Walter H. Feltham & Son Ltd

Imperial Works, Tower Bridge Road
Telephone: HOP 1784 LONDON, S.E.1

TUITION

A.M.I.M.I., City and Guilds, A.M.I.Mech.E., etc., on "No Pass-No Fee" terms. Over 95% successes. For details of Exams and Courses in all branches of Auto., Aero, Mechanical Eng., etc., write for 144 page handbook — Free. B.I.E.T. (Dept. 643), 29 Wright's Lane, London, W.8. {5553

BOOKS

ABACS or Nomograms. By A. Giet. Translated from the French by H. D. Phippen and J. W. Head. Most engineers have made use of nomograms at some time in their careers, and are fully alive to the fact that they are a very convenient tool when the same formula has to be solved repeatedly for several sets of variables. It is fair to say, however, that only a small proportion of even those who habitually employ nomograms know how to construct them for their own use. Most of the comparatively small literature on the subject is written for mathematicians and is extremely difficult for the practical engineer to comprehend. This book is essentially practical, and not only demonstrates the many and varied applications of the abac or nomogram, but shows how even those without highly specialized mathematical knowledge may construct their own charts. 35s. 0d. net. From all booksellers. By post 35s. 10d. From the publishers: Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1.

STEELS in Modern Industry: A Comprehensive Survey by 29 Specialist Contributors. General Editor W. E. Benbow. An invaluable guide for engineers, designers and draughtsmen; it specifies the steels best used in various engineering applications (bearing in mind the present need for economy), describes their general and special properties and characteristics, and how they may be surface finished for anti-corrosive and other purposes. 42s. net, from all booksellers. By post 43s. 6d. from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

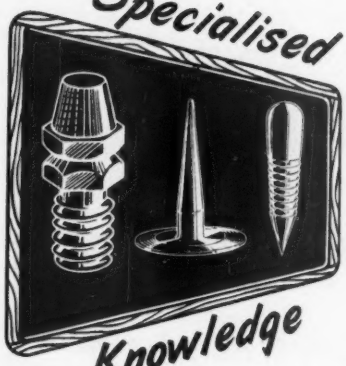
OXYGEN Cutting: A Comprehensive Study of Modern Practice in Manual and Machine Cutting. By E. Seymour Semper, M.I.Mech.E., M.Inst.W. Written to assist engineers concerned with cutting and shaping material, this book describes many of the machines designed for various applications of oxygen cutting to template with multiple heads and also the actual methods of operation. Price 10s. 6d. net. By post 11s. 2d. From all booksellers or from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

GAS Welding and Cutting: A Practical Guide to the Best Techniques. By C. G. Bainbridge. M.I.Mech.E., M.Inst.W. A comprehensive textbook providing practical information on almost the whole range of available gas welding and cutting equipment, methods and processes. Invaluable to the practical welder as well as to those responsible for gas welding and cutting operations involved in the fabrication and repair of industrial equipment. Price 15s. net. By post 15s. 9d. From all booksellers or from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

MATERIAL Handling in Works Stores. 2nd Edition. By L. J. Hoefkens. Shows how the use of fork-lift trucks and pallets in industrial stores can increase production, utilize floor space more effectively, help control of movement and reduce costs. Includes a description of a system actually operated in a modern factory. 18s. 0d. net from all booksellers. By post 18s. 10d. from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

AUTOMOBILE Chassis Design. 2nd Edition. By R. Dean-Averns. A text-book on the fundamentals and technique of design for heavy and light vehicles. This greatly enlarged edition covers all the main components of an automobile apart from the prime mover. 30s. net from all booksellers. By post 31s. from The Publishing Dept., Dorset House, Stamford St., London, S.E.1.

INDUSTRIAL Brazing. By H. R. Brooker and E. V. Beatson, B.Sc.(Eng.), A.M.I.E.E. The first full-length study of this subject. Covers in detail all modern brazing methods, including torch, furnace, high-frequency induction, resistance, salt bath and dip, with chapters on the special techniques necessary for aluminium, stainless steels, beryllium copper, cemented carbides and vacuum tube construction. 35s. net from all booksellers. By post 36s. 6d. from The Publishing Dept., Dorset House, Stamford St., London, S.E.1.



● For automatic and capstan precision parts—in any metal—to your own specifications . . . *consult the specialist machinists.*

I.F.V., D.A.I., D.I.Arm., A.R.B. Fully Approved.

REPETITION PARTS *from the* **BAR** *by* • • • •

Telephone: Broadwell 1115 (4 lines) and 1757

M C L

M.C.L. & REPETITION LTD.

POOL LANE · LANGLEY · BIRMINGHAM

NEW BALL & ROLLER BEARINGS

OVER 4,000,000 IN STOCK
IN MORE THAN 4,000 TYPES

BRITAIN'S LARGEST STOCKS

STOCK LIST AVAILABLE.

CLAUDE RYE BEARINGS
895-921, FULHAM ROAD, LONDON, S.W.6
RENOWN 6174 (Ext. 24)
Cables: Rybearings, London Telex 2-3453

BOLTS & NUTS
MARSDEN
MANCHESTER 1

Samuel Marsden & Son Ltd. Ard 1765

THE BIRFIELD GROUP

is in process of building Research and Development services. Hardy Spicer Ltd., as the largest Group company has the task of establishing an engineering development team and a number of highly qualified engineers have been recruited to this end. Now, as a result of promotion and further growth additional vacancies occur:

1. ASSISTANT DEVELOPMENT ENGINEER

This is a senior appointment calling for an A.M.I.Mech.E. who has served a recognized apprenticeship, had Drawing Office experience, and who has experience of development or experimental engineering preferably in the motor industry. Additionally, the man for this job must have administrative ability, be able to lead a project team, and be competent to undertake technical discussions with senior executives of other organizations.

2. ENGINEERS

Two additional engineers are needed to expand the activities of the Development Department. Applicants must have served a recognized engineering apprenticeship, preferably in the automobile or allied industries. The minimum standard of technical education for these jobs is the Higher National Certificate in Mechanical Engineering and previous experience in a Research and Development Department would be an advantage. The work involved is of a varied and interesting nature and includes the design, development and operation of test equipment, vehicle road testing, instrumentation, project investigation and testing in connection with various transmission components, and dynamometer test work, including the use of electronic equipment and strain gauges.

In each case the salary and other terms of service will be attractive. Applicants are invited to write giving particulars of age, education, training and experience to the Personnel Director, Hardy Spicer Ltd., Birch Road, Witton, Birmingham, 6. Initial interviews will be arranged for suitably qualified applicants at mutually convenient places and times.

DEVELOPMENT MANAGER

A manufacturing Company located in the South of England, wishes to appoint an

EXPERIENCED MECHANICAL ENGINEER

to head a team engaged in the design, development and exploitation of their range of products, which are applicable to the Aircraft, Automotive and Railway Industries.

It is essential that applicants have an inventive mind and an ability to lead.

A good four figure salary is offered with the appointment, which possesses an unlimited opportunity in a rapidly expanding organisation.

Reply stating age, salary required, and previous experience to: T/J Nelson Advertising Service, Eagle House, Jermyn Street, London, S.W.1

ALL REPLIES WILL BE TREATED IN ABSOLUTE CONFIDENCE

F.J. Edwards Ltd

SHEET METAL MACHINERY · MACHINE TOOLS · WOODWORKING MACHINERY

ALL TYPES — NEW & USED ASK for LISTS.

EDWARDS HOUSE, 359-361, EUSTON RD., LONDON N.W.1
Phones : EUSton 4681 & 3771
and Lansdowne House, 41, Water St., Birmingham, 3 (CENtral 7606-8)

Springs

should be lively too!

A Lewis spring is always fighting fit, on top of it's form, ready to meet resistance by night or by day. For lots of technical data you should send 2/6d. for our 40-page manual —just the thing for your design department.

THE LEWIS SPRING CO. LTD. · RESILIENT WORKS · REDDITCH
Telephone : Redditch 720/1/2.

London Office: 122 High Holborn, W.C.1 Telephone: Holborn 7470 and 7479

LEAVE IT TO **Lewis** OF REDDITCH
SPRINGS, SPRING CLIPS
PRESSWORK, WIRE FORMS
VOLUTE SPRINGS

INDEX TO ADVERTISEMENTS

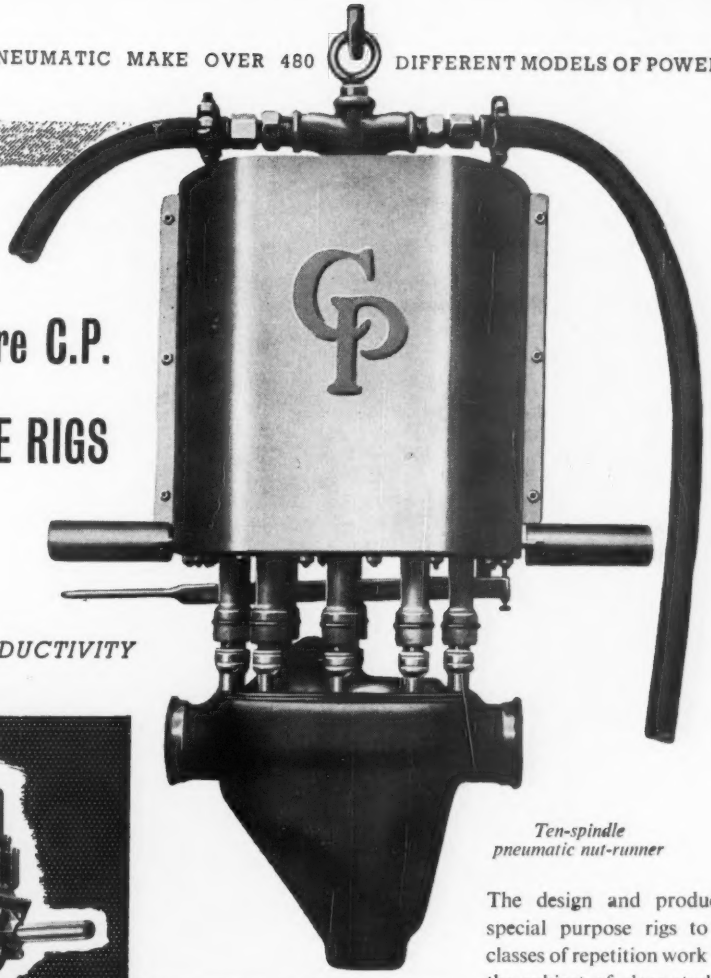
	PAGE
Acrow (Engineers) Ltd. ..	106
Adamant Engineering Co. Ltd.	53
Aircraft-Marine Products (Gt. Britain) Ltd.	68
Almco Simmersheen Division of Gr .. Britain Ltd. ..	109
Aluminium Bronze Co. Ltd.	86
Amal Ltd.	136
Andre Rubber Co. Ltd. ..	67
Angus, George, & Co. Ltd.	28
Archdale, James, & Co. Ltd.	22
Armstrong Patents Ltd. ..	128
Artrite Resins Ltd.	30
Atlas Copco AB ..	Cover ii
Automotive Products Co. Ltd.	5, 6, 7, 8
Aviation Developments Ltd.	38
Avon India Rubber Co. ..	141
Bank of London & South America Ltd.	139
Barber & Colman Ltd. ..	122
Bennett (Hyde) Ltd. ..	114
Benton & Stone Ltd. ..	99
Berry, Richard, & Son Ltd.	94
Birfield Industries Ltd. ..	51
Birlec Ltd.	15
Birmetals Ltd.	111
Booth, James, & Co. Ltd. ..	62
Box No. 8118	140
British Electrical Development Association	119
British Geon Ltd.	85
British Oxygen Co. Ltd., The	18
British Piston Ring Co. Ltd., The	27
British Plastics Exhibition ..	21
British Timken Ltd. ..	39
Brown, David, Corporation (Sales) Ltd., The ..	3, 29, 49
B.S.A. Tools Ltd. ..	Cover iv
Burton Griffiths & Co. Ltd.	Cover iv
Bury Felt Mfg. Co. ..	2
Bushing Co. Ltd., The ..	40
Cape Asbestos Co. Ltd., The	16, 17
C.A.V. Ltd.	60
Charles (Wednesbury) Ltd.	110
Churchill, Charles, & Co. Ltd.	110
Clancey, G., Ltd.	98
Clarkson (Engineers) Ltd. ..	92
Clayton Dewandre Co. Ltd.	54
Consolidated Pneumatic Tool Co. Ltd.	Cover iii
Cooper & Co. (Birmingham) Ltd.	137
Cooper's Mechanical Joints Ltd.	130
Copper & Asbestos Washer Co. Ltd.	98
Courtaulds Ltd.	26
Cross Mfg. Co. (1938) Ltd.	122
Dartmouth Auto Castings Ltd.	69
Deloro Stellite Ltd.	94
Desoutter Bros. Ltd. ..	11
Dobbie McInnes Ltd. ..	136
Dowty Seals Ltd.	114
Drummond - Asquith (Sales) Ltd.	9
Dunford & Elliott (Sheffield) Ltd.	130
Dunlop Rubber Co. Ltd. ..	97
Eagle Pencil Co.	124
Edwards, F. J., Ltd. ..	141
Elgar Machine Tool Co. Ltd.	88
Enthoven Solders Ltd. ..	4
Fairman Precision Tools & Products Ltd.	130
Farnborough Engineering Co. Ltd.	45
Feeny & Johnson Ltd. ..	132
Feltham, Walter H., & Sons Ltd.	140
Fenner, J. H., & Co. Ltd. ..	117
Ferodo Ltd.	36, 37
Finch Watson Ltd.	122
Firth-Derihon Stampings Ltd., The	133
Foden Ltd.	126
Fry's Metal Foundries Ltd.	96
Fuller, Horsey, Sons & Cassell	108
Garringtons Ltd.	128
General Electric Co. Ltd., The	58, 102
Gill's Cables Ltd.	126
Girling Ltd.	77
Gloucester Foundry Ltd. ..	131
Gordon & Gotch Ltd. ..	90
Griffiths, Gilbart, Lloyd & Co. Ltd.	90
Habershon, J. J., & Sons Ltd.	139
Hale & Hale (Tipton) Ltd.	120
Hardy Spicer & Co. Ltd.	105, 141
Harper, John, & Co. Ltd. ..	32
Herbert, Alfred, Ltd. ..	61, 78
Hermetic Rubber Co. Ltd. ..	124
Hey Engineering Co. Ltd. ..	82
High Duty Alloys Ltd. ..	41
Hoffmann Manufacturing Co. Ltd., The	81
Hordern-Richmond Co. Ltd.	88
Hot Pressed Products ..	106
Humphreys, J. H., & Sons Ltd.	126
Hydulignum - Jabroc (Tools) Ltd.	88
I.C.I. (Billingham) Ltd. ..	74
I.C.I. (General Chemicals, Heat Treatment) Ltd. ..	34
I.C.I. (Marston Excelsior) Ltd.	108
I.C.I. (Metals) Ltd. ..	46
Ilford Ltd.	23, 64
Iliffe & Sons Ltd. (Books) ..	120
International Twist Drill Co. Ltd., The	118
Jackson, H., Ltd.	25
Jenks Bros. Ltd.	132
Johnson & Johnson (Great Britain) Ltd.	118
Kirkstall Forge Eng. Ltd. ..	43
Lawrence Bros. Millward Ltd.	128
Laycock Engineering Co. Ltd.	13
Lewis Spring Co. Ltd., The	142
Linread Ltd.	115
Manganese Bronze & Brass Co. Ltd., The	19
Marsden, Samuel, & Son Ltd.	141
M.C.L. & Repetition Ltd. ..	141
Mek-Elek Engineering Ltd.	138
Metalastik Ltd.	33
Midland Motor Cylinder Co. Ltd., The	80
Minnesota Mining & Manufacturing Co. Ltd. ..	138
Morleys (B'ham) Ltd. ..	101
Morris, B. O., Ltd.	113
Moss Gear Co. Ltd. ..	102
"Motor Vehicle, The" ..	138
Neill, Jas., & Co. (Sheffield) Ltd.	116
Newall, A. P., & Co. Ltd. ..	125
Osborn, Samuel, & Co. Ltd.	135
Park Gate Iron & Steel Co. Ltd., The	10
Perry Barr Metal Co. Ltd. ..	57
Philidas Div. of Whitehouse Industries Ltd.	65
Philips Electrical Co. Ltd. ..	93
Plessey Co. Ltd., The ..	73
Pollard Bearings Ltd. ..	14
Power Jacks Ltd.	134
Ransome & Marles Bearing Co. Ltd.	48
Renold Chains Ltd.	12
Rockwell Machine Tool Co. Ltd.	31
Rubber Bonders Ltd. ..	70
Rubery, Owen & Co. Ltd.	82, 103
Rye, Claude, Ltd.	141
Salter, Geo., & Co. Ltd.	..72, 121
Sankey, Joseph, & Sons Ltd.	89
Selson Machine Tool Co. Ltd., The	107
Sentinel (Shrewsbury) Ltd.	91
Sheffield Twist Drill & Steel Co. Ltd., The	47
Shell-Mex & B.P. Ltd. ..	52
Sherborne Rubber Co. Ltd., The	100
Shimwell & Co. Ltd. ..	134
Silentbloc Ltd.	63
Simmonds Aerocessories Ltd.	127
Skefko Ball Bearing Co. Ltd.	Cover i
Smethwick Drop Forgings Ltd.	20
Southern Instruments Ltd. ..	138
Specialloid Ltd.	136
Speed Tools Ltd.	112
Spencer & Halstead Ltd. ..	132
Spencer, H. F., & Co. Ltd.	35
Sterling Metals Ltd. ..	55
Suffolk Ironfoundry (1920) Ltd.	104
Super Oil Seals & Gaskets Ltd.	92
Sutcliffe Speakman & Co. Ltd.	134
Technograph Electronic Products Ltd.	87
Terry, Herbert, & Sons Ltd.	24
Thompson, John, Motor Pressings Ltd.	137
Tilghman's Ltd.	86
Toledo Woodhead Springs Ltd.	59
Torrington Co. Ltd., The ..	50
Triplex Foundry Ltd. ..	112
Tucker, George, Eyelet Co. Ltd.	84
Turner Bros. Asbestos Co. Ltd.	44
Turner Machine Tools Ltd.	104
Udal, J. P., Ltd.	120
University of Birmingham ..	140
Van Moppes, L. M., & Sons (Diamond Tools) Ltd. ..	76
Vaughan, A. J. & Co. (Mitre Works) Ltd.	124
Vaughan Associates Ltd. ..	75
Vaughan Bros. (Drop Forgings) Ltd.	100
Vaughan, Edgar, & Co. Ltd.	56
Vokes Ltd.	129
Wakefield Dick Industrial Oils Ltd.	83
Walker, M. W., & Staff Ltd.	66
Ward, Thomas W., Ltd. ..	96, 123
Wellworthy Piston Rings Ltd.	84
Wickman Ltd.	1
Wild-Barfield Electric Furnaces Ltd.	42
Wiley, James, & Sons Ltd.	116
Wilmot Breeden Ltd. ..	95
Zinc Alloy Die Casters Association	71

Printed in Great Britain for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1, by James Cond Ltd., Charlotte Street, Birmingham 3. "Automobile Engineer" can be obtained abroad from the following: AUSTRALIA & NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd.; Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd.; Wm. Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Co. Entered as Second Class Matter at the New York, U.S.A., Post Office.

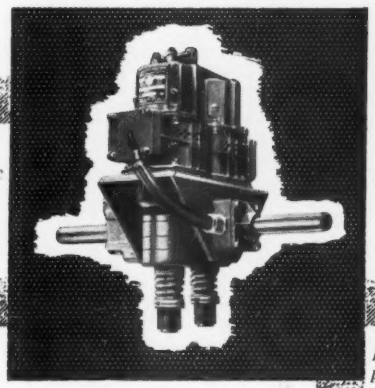
CONSOLIDATED PNEUMATIC MAKE OVER 480 DIFFERENT MODELS OF POWER TOOLS

These are C.P. MULTI-SPINDLE RIGS

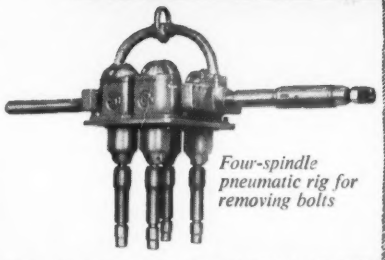
FOR INCREASED PRODUCTIVITY



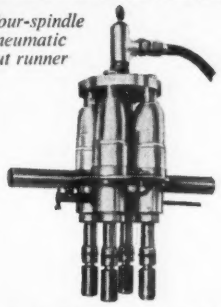
Ten-spindle pneumatic nut-runner



Hicycle electric two-spindle nut runner



Four-spindle pneumatic rig for removing bolts



Four-spindle pneumatic nut runner

The design and production of special purpose rigs to suit all classes of repetition work has been the subject of close study by CP development engineers, and a great variety of these units has been supplied to industry. Standard CP pneumatic stall torque motors or Hicycle electric motors are incorporated in these special rigs for setting all sizes of nuts, bolts and screws. In each case the units can be set to a predetermined torque figure. Each job requires separate consideration, but the illustrations here are typical examples of the types of units which can be produced. Write for catalogue SP 437.

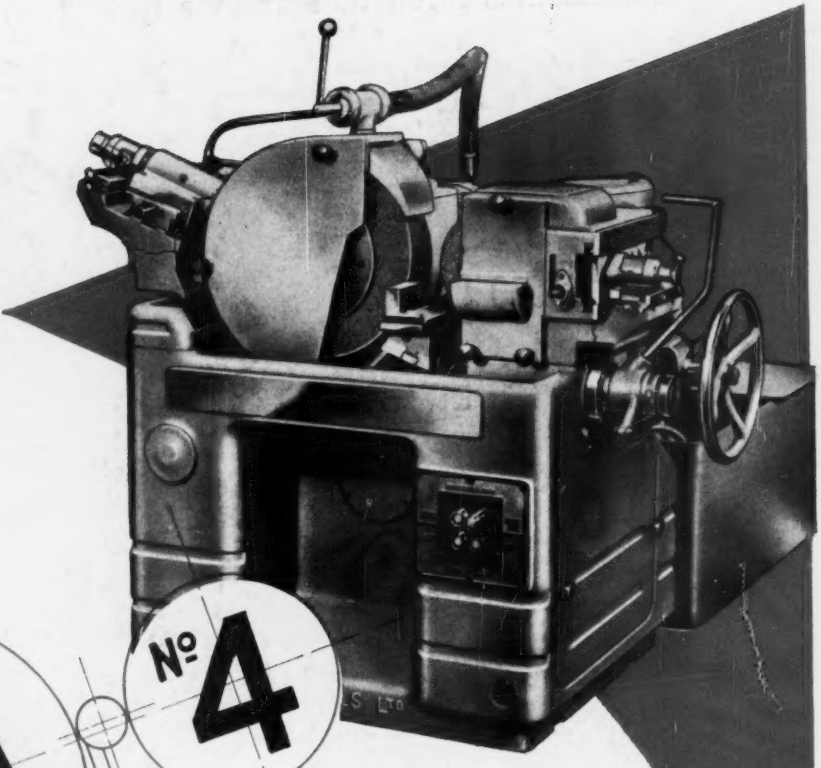
Consolidated Pneumatic

CONSOLIDATED PNEUMATIC TOOL CO. LTD., 232 DAWES ROAD, LONDON, S.W.6

AIR COMPRESSORS · PNEUMATIC TOOLS · ELECTRIC TOOLS · CONTRACTORS EQUIPMENT · ROCK DRILLS · PUMPS · DIAMOND DRILLS

CP128

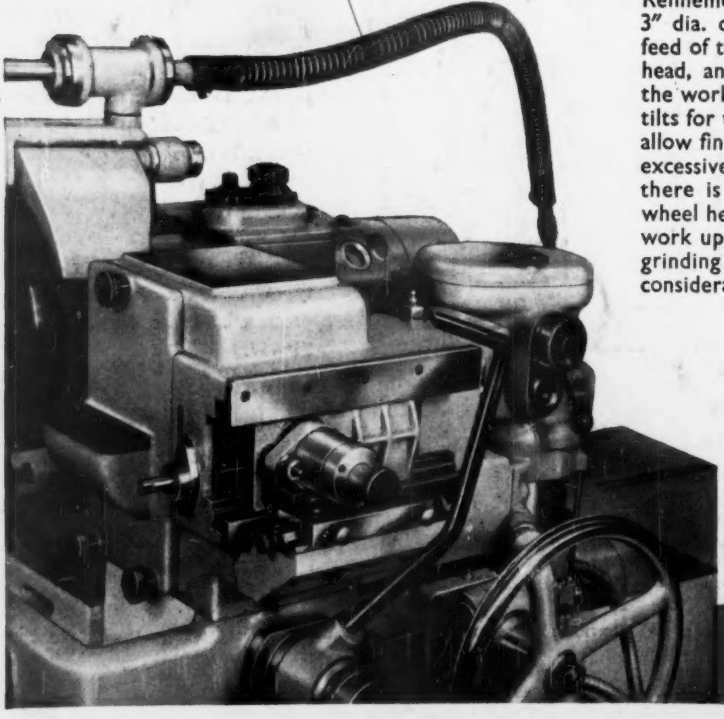
to precision-grind cylindrical parts: plain, tapered, shouldered, special form, multi-dia.



BSA No. 4 CENTRELESS

B.S.A. design makes the adoption of the centreless grinding method—one of the fastest means of finishing cylindrical parts —even more advantageous.

Refinements in the B.S.A. No. 4 machine, 3" dia. capacity, include: extremely fine feed of the grinding wheel by micrometer head, and micro-controlled adjustment of the work base. The control wheel not only tilts for through-feed work, but swivels to allow fine angular correction and, although excessive wheel truing is thereby obviated, there is a separate truing slide for each wheel head. A related machine will take work up to 6½" diameter. B.S.A. centreless grinding machines are deserving of full consideration.



B.S.A. TOOLS LTD
BIRMINGHAM · ENGLAND

Sole Agents Gt. Britain
BURTON, GRIFFITHS & CO. LTD.
KITTS GREEN · BIRMINGHAM
Stechford 3011